CAPITAL AND STEAM-POWER 1750-1800

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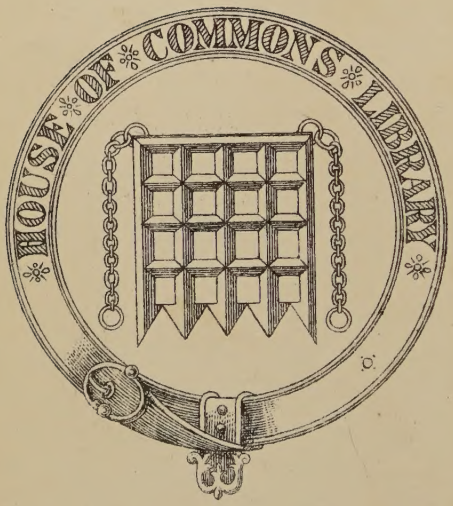

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CAPITAL AND STEAM-POWER

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1750-1800

BY

JOHN LORD,

Bachelor Scholar of Christ's College, Cambridge

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PREFACE

This brief account of the invention of the steam-engine and of its introduction into industry is the result of researches made while I was a Bachelor Scholar of Christ's College, Cambridge. It does not pretend to be a complete account of the state of industry in the eighteenth century, but only deals in detail with such trades as were intimately connected with the steam-engine, and such as early adopted it as a power unit.

The essay is largely based upon the papers of the pioneer engineering firm of Boulton & Watt. These papers are at present in the City of Birmingham, and are housed in two separate places under two different controls. The first of the collections is kept in the Central Municipal Reference Library, and though it contains valuable material illustrating the history of the city, the Birmingham Free Library Committee have not as yet seen their way to spend money upon cataloguing and arranging it; this is in some measure due to the war. The history of this collection is simple. It contains the records of the firm, and comprises letters to and from the partners, wage books, cash books, engine books, and a large amount of

miscellaneous material that accumulated during a period of 100 years. The records extend from 1775 to 1850, when the firm was dissolved and the Soho works were sold. The papers, at this date, came into the hands of the successor of the engine business, Sir Richard Tangye, who, with a right sense of the value of the inheritance, had the papers carefully preserved, and an exhibition of the more interesting engine drawings and models displayed in a part of the works. These papers were presented to the Corporation of Birmingham, in 1913.

The second collection is situated in the Assay Office, Birmingham, and is the property of Miss Boulton, of Tew Park, a direct descendant of Matthew Boulton. It was temporarily deposited in the Assay Office in 1920, after Miss Boulton had left Tew Park. It contains information of unequalled importance, comprising many private letters between Boulton and Watt, and many statements and documents of a confidential nature, bearing not only upon the development of the firm, but also upon the relations of the partners with other important political and industrial figures of the time.

The great difficulty in dealing with the papers is the almost entire absence of order among them,[1] and the non-existence of any

[1] Except in the firm's letter books, which were very carefully kept.

sort of catalogue. They have previously been worked upon by that indefatigable biographer, Smiles, and it is time that Thorold Rogers' estimate of the value of Smiles' industrial histories was revised.[1] The *Lives of the Engineers* are a valuable contribution to the literature of economic history. They contain information which entitles them to be considered as original sources, and they emphasized the value of the papers of industrial enterprises when such records were treated with supreme carelessness. Nevertheless, it is true that among much that is valuable in the work of Smiles, there is a certain amount that is influenced by his desire to emphasize the principles of Self-Help, which he regarded as responsible for all progress. In fact, he was a thorough-going Utilitarian, and, moreover, he was not able to see the exact position which his contribution occupied in relation to the whole story of industrial development. Therefore, it seemed desirable to disregard the work of Smiles, except where confirmation was possible, or where it seemed probable that he possessed first-hand information.

My thanks are due to Miss Boulton for her kindness in permitting me to have access

[1] Thorold Rogers, *Economic Interpretation of History*, p. 267. He deprecates the need for spending time, in an economic history course, on details of industrial history. The story of the industrial inventions has "employed the leisure of Mr. Smiles, and the leisure of Mr. Smiles was very respectably employed."

to the documents which belonged to her; also to the Librarians at the Reference Library, Birmingham, and to the Master of Assay, for their courteous assistance while I was at work upon the papers. I wish also to express my gratitude to Mr. C. R. Fay and Mr. R. W. Stanners, under whose guidance this essay was begun; and, lastly, to my father, to whom, in the capacity of kindly critic, I am specially grateful.

JOHN LORD.

The University Settlement,
Liverpool.
July, 1923.

NOTE

The various collections of papers have been referred to as follows:

Collection at the Reference Library, Birmingham ..	Tangye MSS.
Collection at the Assay Office, Birmingham	Tew MSS.

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CHAPTER I

Introduction

(1) *The Records of Boulton & Watt*

The development in economic organization that took place in the eighteenth century in England, is one of the most important occurrences in world history since man first discovered the use of fire. It is the story of the harnessing of steam-power to the service of mankind, and the effect of this discovery on the slowly moving economic evolution that had begun with the beginning of time.

The story of labour in this period is the story of specialization, of the separation of functions, and the evolution of classes. It is connected with the story of population, enclosures, political classes, and wage payments. While at first the accumulation of capital is the story of mines and land, and the parallel story of foreign trade, foreign wars, and foreign possessions, there then comes the application of capital to industry, firstly for the purchase of raw materials and the payment of labour, and later for the establishment of fixed capital. Just as the first story is the change from commercial to industrial capital, so the latter is that of trading capital becoming concentrated in the fixed means of

production. The story of the relative shares of capital and labour in production and consumption is the story of increasingly powerful machines and increasingly mechanical workmen, accompanied by the development of economic and political classes and the slow penetration of capital downwards through them.

Though this is the general trend of economic development in the eighteenth century, the account is necessarily vague. Too many hasty generalizations have been coined about this important stage in history. As yet not one quarter of the immense amount of material which exists on the period has been completely worked, and the truth can only be obtained by working at corners of the vast mosaic. No store of information has been so neglected as the papers and documents of the firms which grew, developed, and died during the period known as the Industrial Revolution. Among such collections the papers of the firm of Boulton & Watt are important, not only as those of a typical firm, but as the record of a pioneer engineering firm which for twenty-five years was the sole source of steam-power in Great Britain.

(2) *The Origins of Capital*

Capital existed from the first moment when primitive man saved something he had produced and could have consumed, in order that he might in the future produce something more with its help. Economists to-day differ as to what they shall

include in their definitions of capital, but they are all agreed that its two main qualities are " productiveness " and " prospectiveness," both of which are as plain in the most primitive, as in the most modern and complicated form of capital.[1]

Nevertheless, in mediaeval and early modern times the accumulation of capital was hampered and restricted in many ways. In the first place, it is obvious that the prime source of all capital must be the free gifts of nature mainly consisting in land and mines.[2] Until 1700, in England, it is chiefly to agriculture that we must look for the saving, that provided us with sinews for, what has become known as the Industrial Revolution.[3] But the accumulation of capital in agriculture, in an ignorant and ill-organized state, obviously had very serious difficulties and limitations. Firstly, the perishable quality of much of the production, in the absence of quick transport and well-organized markets, made saving difficult. Moreover, the almost universal distribution of land among all classes of the community kept the demand for agricultural produce small, and in many cases any surplus produce must have gone to waste.

Again, the lack of ample circulating media in the shape of gold and silver, combined with the mediaeval superstition against usury, not only made invest-

[1] Böhm-Bawerk, *Positive Theory of Capital* [trans.], p. 100 and note. Marshall, *Principles of Economics*, Bk. II, Ch. IV, p. 81, Appendix E, pp. 784–90..

[2] Marshall, *Industry and Trade*, p. 51.

[3] Ernle, *English Farming Past and Present*, pp. 148–9.

ment difficult, but actually closed many avenues that might have been both productive to the community, and profitable to the individual. Moreover, potential capital was drained away along other channels. In the Middle Ages much capital was invested in ecclesiastical buildings which were not directly productive. Also our carrying, and even much of our inland trade, were in the hands of foreigners,[1] while our wool was taken to the Continent, manufactured into cloth, and then re-imported into this country. All these operations meant a wastage or a failure to take advantage of means of accumulating capital.

(3) *Early English Trade and Industry*

The story of English industrial development is long and complicated, and its early history is still a matter of controversy among economic historians. Nevertheless, it is almost certain that at the end of the seventeenth century the "gild merchant" had become a mere town council, an exclusive aristocracy that concerned itself only with municipal affairs; while the other great organization, the craft gilds, had been very much broken by a process of amalgamation and evolution of classes that was incompatible with the rigidity of the mediaeval system.

The organization of trade precedes that of industry[2] and the members of the gild merchant in the

[1] *Social England*, ed. Traill. Vol. V, p. 164.
[2] Ashley, *Economic History*, Part 1, p. 77.

earliest days of town life had acquired the exclusive rights of buying and selling, and had become a wealthy and powerful class long before the development of local industry had reached the stage of conscious organization. When the workers in industry became more powerful, and, with the penetration of capital downwards, attempted to trade on their own account, their claim was desperately contested by the established authorities of the gild merchant. However, the craft gilds proved the more powerful and were victorious ; they are the source of all our later commercial and industrial classes, and this displacement of the gild merchant by the craft gild as the controlling force in industry, corresponds to a parallel displacement of trading capital by industrial capital.[1] The craft gild was a combination of the master craftsmen in any one trade, or less commonly in a combination of allied trades,[2] in a mediaeval town ; and, as most of the necessaries and some of the luxuries were supplied locally, most towns had a fairly complete set of craft gilds by the fifteenth century. By this date industries had so far developed as to make organization essential, but the time had not yet come when the rules of the gilds were considered as obstructions to further progress.

In the infancy of an industry, the master-craftsman combined in his own person the duties of employer, workman, foreman, merchant, and shop-

[1] Unwin, *Industrial Organisation in the Sixteenth and Seventeenth Centuries* Ch. I, *passim.*

[2] *Ib.*, p. 19

keeper; but during the fifteenth and sixteenth centuries industry developed and a division of these functions took place. The master-craftsman tended, more and more, to confine himself to the duties of employer, merchant, and shopkeeper, thus allowing the journeymen whom he employed to achieve comparative independence, and with the assistance of a very small amount of capital to set up as a small master himself. Following this line of development, there gradually evolved, from the original single class of craftsman,[1] the trading master, controlling a fairly large capital, who undertook the duties of buying the raw material and selling the finished product; the small master-craftsman, taking his raw material from the trading master, manufacturing it and returning the finished product to the man from whom he purchased his raw material.

The next stage of development is important. Some of the small masters gradually acquired capital of their own, either by a decline in the position of the trading masters, or by exceptional enterprise and diligence on their own part. As their capital gradually increased they were able to meet the trading capitalist on an equal footing, but instead of assuming similar trading functions they began to employ a larger number of workmen, and organized their industry on an increasingly large scale. The whole trend of English industrial development is for capital to be applied more and

[1] Professor Unwin, in his *Industrial Organisation*, has two very illuminating diagrams which illustrate the separation of functions and the evolution of classes.

more to the actual operation of producing, and less and less to the transactions of buying and selling. This process of class formation occupied about four centuries, from the thirteenth to the seventeenth, and at the date we have taken the classes in existence were roughly :

These class distinctions were made more definite by the adoption of constitutional forms by the gilds, the assumption of control by the trading section, and the exclusion of the poorer members from the attainment of mastership. The essential classes in industrial organization during the sixteenth century were the trading master represented by the Livery Companies, and the small masters represented by the yeomanry organization that had once belonged to the journeyman.

(4) *The Seventeenth Century*

In the seventeenth century, the gild organization began to decay. The number of wants that

[1] Unwin, *op. cit.*, p. 13.

had to be supplied from a distance was increasing, and international trade had become the opening for the activities of the organized merchants. Moreover, industries began to be concentrated in localities which were peculiarly suitable for them, and instead of each town producing all it required, one specialized in hats while another concentrated on making gloves. Where this happened, the gild system was commonly superseded by a domestic industry, in which the merchant class put out the raw material to craftsmen working in their own homes. Thus the increase of capital and the division of labour went side by side, and both were bound up with and controlled by the extension of markets that had been going on since the days of Elizabeth. An increase of capital made the master-craftsman a merchant, and his journeyman a small master ; while the specialization of towns increased the scale of the industry, and made the industrial as opposed to the commercial element in production of greater importance. The gild system was undermined by the same two influences that made for expansion in commerce and industry. In the *Discourse of the Common Weal* the author divides all artificers into three classes :

" Off the first, I reckon all mercers, grocers, vinteners, haberdashers, milleyners, and such as doe sell wares growing beyond the seas and doe fetch out our treasure of the same. . . . Of the second sort be these : shoemakers, tailors, carpenters, masons, tillers, bowchers, brewers, bakers, vitailers of all sorts which like as they get their living in the country so they spend ; but they

bring no treasure unto us. Therefore we must cherish well the third sorts, and these be: clothiers, tanners cappers, and worsted makers only that I know which by their misteries and faculties doe bring in any treasure."[1]

No doubt all this time there were people who combined in their own person the functions of a merchant employer, a retail shopkeeper, and a trader overseas, but, generally speaking, the industrial capitalist was separated from the trading capitalist.[2]

This gradual evolution of economic classes and development of industrial organization is intimately connected with the accumulation of capital, which depended upon the produce of land and mines and, in the seventeenth century, more particularly upon the success and produce of foreign trade.

(5) *Beginning of the Eighteenth Century*

Side by side with this evolution of economic classes from the gilds, another movement was

[1] Lamond, *Discourse of the Common Weal*, p. 91.

[2] Unwin, *op. cit.*, p. 72. "The company of Glovers (Chester) contained two separate classes, the leather dressers or wet glovers, who traded across St. George's Channel at their own risk for the skins, and the dry glovers, who bought the skins by dozens and half-dozens and worked them up in their homes. Towards the expense of the New Haven the Glovers' Company in 1567 gave 1s. 7d. a week, or more than six times the amount of the cappers' contribution, and in the same year we find a glover, no doubt a wet glover, sitting along with the leading shop-keepers, the drapers, ironmongers, mercers, etc., on a committee appointed to regulate the retail trade of Chester." R. H. Morris, *Chester*, pp. 435, 461, 464.

going on. Industries were growing up that had no mediaeval antecedents, and these industries were of two kinds. Firstly, many of the domestic operations that supplied family wants directly were becoming the business of specialized workmen to a greater extent than ever before ; while in the second place, many wants that had formerly been supplied from abroad, by the gradual immigration of foreign workmen were becoming naturalized in England. Though these new industries conformed to the traditional organization of the other trades, they had none of the rigidity and importance which made progress difficult ; and it is to these industries that we must look for the great expansion of the eighteenth century. The textiles possibly employed fewer people at the end of the eighteenth century than they did at the beginning, though actually the total hours spent at work was greater and the production per man was increased a hundred fold.[1] It is to industries like engineering, pottery, hardware, coal and iron-mining, that we must look for the development of industry in the industrial revolution.

The economic classes which the gilds had produced were the classes which now entered the new industries. The capitalists of the seventeenth

[1] There is a doubtful quotation on this head in Burnley, *Wool and Wool Combing*, pp. 79–80 : "The influence of machinery on the wool trade . . . At the rate of production in 1738, a million and a half persons would be required to work up the annual growth and importation of wool into cloths whereas rather less than one hundred years afterwards only three hundred and fifty thousand operatives were required."

century to a large extent provided the capitalist class of the eighteenth, while the journeyman of the gild system were the nucleus of the industrial wage-earning class that developed under the new capitalist system. There was no break in continuity, no industrial *revolution;* the movements that were so slowly working out in 1700 became more rapid as the century progressed, and the application of steam-power to machine industry hurried on the change so quickly that the idea of evolution is somewhat hard to trace. The gilds provided both the capital and the labour for the industrial expansion of the eighteenth century, and if in some cases they flowed along old channels and in others along new, their ever-widening power had as its sole source the old gild organization.

When the eighteenth century opens, the gild system was composed of large masters and merchants, small masters, journeymen, and apprentices. The small masters and journeymen were practically excluded from any power in the gild, and they began to form unions of their own to protect themselves.[1] Even before the Civil War the small master was being driven to take his stand alongside the journeyman; but common interests were strong enough to preserve the unity of the gild, and, moreover, the Long Parliament refused the craftsmen incorporation. The refusal was not without its compensations, for many of the employing class made concessions to the rank and file.

This democratic movement *inside* the companies

[1] Unwin, *op. cit.*, p. 209.

was the last rally of a dying cause, and, as far as its immediate object was concerned, the practical result was slight. After the Restoration, it disappeared altogether, although there was still a possibility that the excluded class would gain incorporation and have legal authority for the defence of its interests.[1] At first, the question of incorporation was argued on the grounds of expediency, and the opposition usually urged that the proposed new grant would be an encroachment on the privileges of an existing corporation, and would weaken the authority that controlled the industry. Apart from these considerations, it was not claimed that the privilege of incorporation belonged to any one class: and thus the small masters, who were still master-craftsmen with journeymen and apprentices under them, seemed to be the nearest heirs of the traditions of the old craft gild.

Gradually, as the functions of craftsman and trader became more and more distinct, and as the latter gained control of the London gilds, and the former sank into a position of subordination and dependence, the idea arose that an incorporation of craftsmen was a dangerous thing. The City Council, as representing the main interests of capital, opposed all new incorporations.[2] The workmen tried to obtain incorporation and to form combinations. For instance, the sawyers, who were labourers working by the day for wages, or by the load, upon

[1] Unwin, *op. cit.*, pp. 210–11.
[2] *Ib.*, p. 212.

material provided by their employers, attempted to secure incorporation, but the carpenters, in conjunction with the shipwrights and joiners, who employed the sawyers, united to prevent this. By their failure along these traditional lines, the wage-earning class was driven into secret combinations, from the obscurity of which the trade union did not emerge till the nineteenth century.

The intervening eighteenth century was a time of rapid growth; the hampering influence of the gild disappeared not by the thrusting from below, but from the mere fact that industry grew beyond it, and there was no need for the regulations and rules of the gild. The growth of trading capital by separating the craftsmen from direct contact with the market gave rise to those intermediate forms of industrial organization which are grouped together under the domestic system. "The decay of those forms and their ultimate displacement by the factory system was due to the growth of industrial capital." As long as the small master owned much of the industrial capital required for the exercise of his calling, he was not a mere wage-earner, however much he might be dependent on the capital of the trader. With the appearance of the industrial capitalist, who organized manufacture on a large scale, and supplied not only the circulating but sometimes also the fixed capital, the small master was reduced either to the position of a mere journeyman or of a wage-earning master who, economically, was indistinguishable from a journeyman.

The labour troubles of the eighteenth century were partly caused by the efforts of this class of small masters to organize themselves along with the journeymen on a common footing as wage earners. However, the importance of *laissez faire* in the eighteenth century is not to be minimized; and the passing of the Combination Acts and the early prosecutions of trade unionists should not blind us to the fact that it was the comparative freedom of England in the eighteenth century that made the combination of wage earners possible.

(6) *The Early History of Capitalism in England*

Since the reign of Elizabeth and the discovery of gold and silver in South America, the material means necessary for the accumulation of capital had become almost universally accessible. Payment in kind had been replaced by money payments, and with money payments came the possibility of saving.

This alone, however, would not have been so important had not another and more far-reaching change taken place in the economic organization of the country. The restrictions upon usury imposed by the Church, and supported by patriotic and anti-Semitic opinion in the Middle Ages, had been broken down, and greater facilities were offered for the transference of accumulated wealth to the men who would use it productively. Moreover, the discoveries of the sixteenth and seventeenth centuries had opened new trade routes all over the

world, and the consequent extension of markets offered many profitable openings for capital to be invested in commercial enterprises. In every direction the bonds that had hampered the accumulation of capital were being broken, and the way opened for the rapid development of capitalist organization which took place in the seventeenth and eighteenth centuries.

The early history of the accumulation of capital in England is very obscure, especially as most enterprises were either one-man businesses or simple partnerships, where all decisions were informal and hardly ever recorded. This was the state of affairs under the gild system, and the lack of evidence from this quarter increases the importance of the history of the joint-stock companies, which kept records and played a large part in the accumulation of capital even before 1720.[1]

Their story begins in the period of reconstruction following that of economic loss due to the redistribution of wealth which accompanied the Reformation, when the capital of the country was being depleted to pay the interest on foreign debts, and when the consequent necessity for higher returns to the remaining capital forced investors to pay greater attention to foreign trade, with the result that the great foreign trading companies were founded.[2]

These foreign trading companies, like the East

[1] Scott has written an exhaustive account of joint-stock enterprise in the British Isles to 1720. Scott, *The Early History of Joint-Stock Companies to* 1720.

[2] Scott, *op. cit.*, Vol. I, p. 17.

India Company, the Russia Company, and the Hudson's Bay Company, were all floated with what seems to be a very small amount of capital, and made tremendous profits.[1] Sixty per cent was counted poor,[2] while from one of the buccaneering voyages in Elizabeth's reign the adventurers made a profit of 4,700 per cent.[3] So popular and so successful were these companies that the joint-stock system was imitated for the development of the internal resources of the kingdom, and before the end of the sixteenth century, various industrial enterprises had been founded on these lines.

These industrial enterprises were mainly, though not wholly, confined to mining, water supply, and drainage. Some few there were, mainly in the seventeenth century, which were founded to produce some new invention, and a rather larger number which were founded to finance monopolies. Later still, banking became a legitimate and successful opening for joint-stock capital. All these companies were probably quite efficient and undeserving of the criticisms levied against them by Adam Smith.[4] However, at the end of the seventeenth century, the capital of these joint-stock companies was increasing rapidly. In 1695 the approximate total invested on the joint stock principle was £4,250,083, while in 1703 the total is estimated at £8,447,401.[5]

[1] Russia Company was floated with £6,000 capital. *Ib.*, p. 22.

[2] *Ib.*, p. 43. [3] *Ib.*, p. 81. [4] *Ib.*, Vol. I, *passim.*

[5] Thorold Rogers' *Industrial and Commercial History of England*, p. 125. The value of the stock rose rapidly and the increase in material stock was probably much less than it would appear. Scott, *op. cit.*, pp. 335–6, 371.

At this time (1695) it is estimated that the industrial wealth of England, without agriculture, was 33 millions, thus the joint-stock capital formed about 12 per cent of the total.[1]

It is again worth emphasizing that the accumulation of capital has two stories: one, the evolution of economic classes depending for their status on the amount of capital they held, and, second, the actual development of the resources of the country and the increase in the stock or capital of the community as a whole. With this in mind it is important to realize that besides the capitalists normally evolving from the gild system and retaining their position at its head,[2] there were other capitalists whose capital was not necessarily drawn from industry or commerce and who had little or no connexion with the business in which their capital was invested. This was obviously true of the adventurers who invested their money in buccaneering enterprises under Elizabeth, and it now appears that even in the definitely trading companies a large non-mercantile element invested their money from the beginning; while at a very early date shares were bought and sold with a considerable degree of freedom.[3]

Thus there was growing up a volume of industrial and commercial stock which was held by people

[1] *Ib.*, p. 337.

[2] *Vide supra*, pp. 4–7.

[3] Scott has definitely proved that free sales of shares took place in the sixteenth century, and disproved the theory which said that the first free sale of stock took place in the eighteenth century. *Ib.*, pp. 492–3.

who were out of touch with industry and commerce. Probably these people obtained much of their surplus from land; though by 1700, commerce and inheritance were contributing their shares to the initial capital of new enterprises. In fact, it was these sources which provided the capital necessary to develop the mineral resources of the country, and, with the help of the steam-engine, to add so greatly to England's material capital in the eighteenth century.

CHAPTER II

General State of Industry, 1700–1750

(1) *Introductory*

The history of the development of the textile trades and their organization after 1600 is the story, first of the development of a capitalist class, the clothiers, who provided the raw material for their poorer folk to work up in their own homes, paid them wages and sold the finished product ;[1] later, of the rise of the small, energetic capitalists to rapid fame and fortune.[2] It is a story that has been often written, and has been taken as typifying the development of capitalism in all industry ; but the non-textile trades provide as interesting a story, and one that does not follow exactly the same course, and it is with them that we are principally concerned.

In the period 1700–1750, practically all the trades and industries that exist to-day had their beginnings. It was in this period that capital was really invested in mines and a great return received.

It is necessary to summarize what has already been said of industry in the seventeenth century before the lines of development in the early eighteenth can be made clear. The main point is that localities were no longer self-contained indus-

[1] Daniels, *The Early English Cotton Industry*, p. 30–33.
[2] Gaskell, *Artisans and Machinery*, pp. 94–5.

trially. Mining, which had always been a localized industry, led the way. Then agriculture followed; the slopes of the hills were the best grazing in the country, and the sheep farms were fixed on the Pennines, Salisbury Plain, and in Suffolk, where large stretches of heath and common made sheep farming profitable.

The fact that specialized agriculture and mining were early located in various parts of the country meant that the allied industries of spinning, weaving, and tanning, smelting and rough metalwork also began to be localized. Developing parallel with this, however, were the other industries that had grown out of the "miller-blacksmith" type of work, e.g. the leather workers, the potters, the farm implement makers, the hardware makers, the brewers, the millers, none of whom had anything in common with the development of the textiles, and whose economic organization in the eighteenth century was different.

Moreover, there were the water companies, the canal companies, and the shipping companies which, though they were closely connected with the regulated companies, yet were not examples of the development that is seen in the textile trades. At the beginning of the eighteenth century all these latter industries were becoming fixed in definite localities—Macclesfield specialized in buttons, Reading in malt, Bridport in hemp,[1] and so on. The two

[1] *Present State of Great Britain* (1745), p. 20: "London is largely supplied with meal and malt by Reading barges, some of which will carry a load of twelve hundred ton."

influences that made for this result were either the particular suitability of the town or the type and training of the people in it. The first cause is obvious, but the second has not as yet been sufficiently emphasized.[1]

(2) *Coal-Mines and Iron-Works*

There is a history of geographical discovery other than the chronicle of long voyages and hazardous expeditions, it is the story of the discovery of the mineral wealth of a country. This task of discovery, started in England by the monks and the Jews, and carried on by the lay landlords, was turned into a financial success by capitalists from other industries in the eighteenth century, and finally taken over by the Government in 1835.[2]

For the greater part of history, wood was the obvious and most universal fuel. The monks are usually credited with the introduction of coal as fuel, for in 852 the Abbey of Peterborough received twelve cart-loads " of fossil or pit-coal."[3]

During the Middle Ages the coal trade continued to develop, especially in Northumberland and Durham, where in 1239 a charter was granted to

[1] W. J. Ashley, *Brit. Assoc. Handbook Birmingham*, 1913, p. 356.

[2] *Memoir of the Geological Survey of Great Britain*, 1835.

[3] R. Meade, *The Coal and Iron Resources of the United Kingdom*, p. 1 : It seems doubtful whether many of the discoveries and achievements in art and industry which are attributed to the monks are their just due. There is a strong probability that the fact that the monasteries kept records and wrote histories when the activities of the rest of the world were unchronicled, secured their claims to invention and discovery.

the freemen of Newcastle-on-Tyne to dig coals in the castle fields. From this time considerable quantities began to be used by brewers and smiths,[1] an extension of use that was quickly followed by complaints about the injurious effects of the smoke. In 1379 the first tax was laid upon coals, and in 1421 a duty of twopence per chaldron was paid to the Crown by all persons, not franchised in the port of Newcastle, who bought coals.[2]

The development of the coal industry continued, and provides an example of the chaotic condition of early economic legislation. On the one hand, the Government was endeavouring to conserve its timber for shipbuilding by enacting penalties against the felling of trees "to make coals for burning irons," and on the other, the burning of pit-coal was prohibited by commission from the King, and fines were levied to prevent it.[3]

The early methods of coal mining were rude and ineffective, shallow bottle-necked pits being universal, which, owing to the impossibility of drainage, had to be abandoned after a very short period of

[1] Meade, *op. cit.*, p. 1.

[2] *Industrial Resources of Tyne, Wear, and Tees*, p. 7.

Jusserand, *English Wayfaring Life in the Middle Ages*, p. 235, n. (i): "The English coaling trade had greatly increased in the fourteenth century; large quantities were brought by water from Newcastle and other places to London and partly consumed on the spot, partly exported."

[3] Scrivenor, *History of the Iron Trade*, 1854 Edition, p. 35–6: "In 1558 an Act was passed . . . that no timber of the breadth of one foot square at the stub and growing within fourteen miles of the sea . . . shall be converted to coal or fuel for making iron."

Further Acts limiting the places where trees could be felled were passed in 1581 and 1583.

working. However, the demand increased, and as the restrictions on the use of wood for smelting iron became more vigorous, efforts were made to use pit-coal for this purpose. In the reigns of James I and Charles I, many persons unsuccessfully attempted to do this.

As a result of their non-success, in many parts of the country iron works were closed down.[1]

Dud Dudley became manager of his father's iron works in Worcester in 1610, and he successfully smelted iron with coal.[2] He says, "Wood and charcoal growing then scant and Pit-coal in great quantities abounding near the Furnace did induce me to alter my furnace, and to attempt by my new invention, the making of Iron with Pit-coal, assuring myself in my invention the loss to me could not be greater than others, nor so great, although my success should prove fruitless. But I found such success at first trial animated me; for at my tryal or blast I made Iron to profit with Pit-coal, and found *facere est addere Inventioni*."[3] Dudley, however, was unfortunate in his enterprise, for his works were swept away in a flood, and on restarting his fellow ironmongers attacked him so fiercely, both on the ground of monopoly in Parliament, and

[1] Scrivenor, *op. cit.*, p. 37.

[2] Doubt has been cast on the justice of Dud Dudley's claims by recent antiquarians.

A. Rollason, *Seamy Side of Dud Dudley*, 1921.

[3] Dud Dudley, *Martellum Martis*, reprint of 1665 Ed., p. 4. Sturtevant, a German, skilled in mechanical operations, was the first to try to smelt iron with coal. Several other foreigners also made unsuccessful attempts. See Sturtevant, *Metallica*; Smiles, *Industrial Biography*, p. 45–6.

as defenders of the workmen, through mob violence outside, that he was compelled to close down.[1]

During the Civil War the iron trade had a bad time, and it was not until 1713 that coal smelting was revived as a profitable undertaking. In that year Abraham Darby again attempted to use coal for smelting iron in his furnace at Coalbrookdale.[2] Thus the country was on the eve of a tremendous increase in the demand for coal, for agriculture was improving its methods and ever increasing the amount of land under cultivation, and sweeping away the tracts of forest that had formerly kept the furnaces employed.[3]

More coal was needed, could the coal-mines supply it? The depth of the pits was increasing, and the difficulty of keeping them free from water was consequently growing greater; however, the increased demand stimulated the improvement of pumping machinery. Cunningham quotes the case of a Mr. Beaumont, who in 1649 " adventured into our mines with his thirty thousand pounds and who brought with him many rare engines, not known

[1] Smiles, *op. cit.*, p. 45–53. He followed the fortunes of the king, but like many others he failed to obtain compensation at the Restoration.

[2] *Philosophical Transactions*, 1747: " Mr. Ford from iron ore and coal both got in the same dale (Colebrook) made iron brittle or tough as he pleases, there being cannon thus cast so soft as to bear burning like wrought iron." Whether Darby used pit-coal is uncertain. Smiles says he can find no record and gives the whole credit to Ford, who was Darby's son-in-law, and manager at Coalbrookdale in 1747. This will be clearer when the records of that firm are finally analysed by Mr. Ashton, of Manchester University, who has been working on them.

[3] Adam Smith, *Wealth of Nations*, p. 152.

then in these parts : as the Art to boore with iron rodds to try the deepnesse and thicknesse of the coale, rare engines to draw water out of the pits—within a few years he consumed all his money and rode home upon his light horse."[1] The development of pumping machinery, however, is due, not to the coal miners, but to the adventurers in the Cornish tin and copper mines, who had experienced the difficulty much earlier, and to them is due also the introduction of various types of power from complicated windlasses to the steam-engine itself.

The localities in which the coal had been worked to any great extent at the end of the seventeenth century were surprisingly small. There is no doubt that at this time the Newcastle coal-field was easily the most important as it was also the first to be worked.

Dudley, in Worcestershire, was the centre of an iron and coal industry, and Coalbrookdale, in Shropshire, was also a busy coal-mining area, but the main producer of coal was Newcastle. The fact that London's full supply was carried by sea from the north gave it the name of " sea-coales."[2]

[1] Cunningham, *Industry and Commerce*, Vol. II, p. 529.

[2] The port of Newcastle vend rose as follows :

1602	.. ..	190,600
1609	.. ..	239,261
1621	.. ..	345,540
1630	.. ..	289,922
1660	+ Sunderland ..	537,000
1700	„	653,000
1710	„	650,000
1750	„	1,193,457

Industrial Resources Tyne, Wear, and Tees, p. 20.

It is then fair to assume that London chiefly used its coal supply for domestic purposes, and that away from the actual coal-fields little coal was used in industry, and it is to the fact that our coal and iron seams are found close together that the development of both our coal and iron resources are due. Consequently, during the next century we have to look to the neighbourhood of the coal-fields for the development of the iron trade. In the north, at Gateshead, an iron works was opened in 1747, an establishment which has developed into one of the largest engineering works on the Tyne;[1] while in 1793, millwright work was undertaken at Chester-le-Street, where paper, lead, corn, and other mills were constructed for all parts of England, Scotland, Ireland, and abroad.

But the more interesting coal-fields for their connexion with the early iron industry were those of Furness and Staffordshire. These are interesting as the cradle of one of the pioneers in iron-work and engineering, who did so much to develop the industry and improve it. Some time after the beginning of the eighteenth century Isaac Wilkinson occupied a small farm either in Cumberland or Westmorland, and also was employed as a workman, or perhaps as an overlooker, in one of the numerous haematite iron furnaces and forges in that part of the kingdom.[2] In 1740, Isaac, who had been receiving about 14s. a week, removed to the village

[1] *Industrial Resources of Tyne, Wear, and Tees*, p. 291. The firm in 1864 was Hawks, Crawshay & Co.

[2] H. W. Dickinson, *John Wilkinson, Iron Master*, p. 6.

of Backbarrow, in the parish of Coulton, in Furness, where he had a house, and began to make flat iron heaters with the assistance of his eldest son, John. They had, at first, no furnace of their own, but got their melted metal from a furnace across the road, bringing it over in large quantities and pouring it into moulds. However, in 1748, or perhaps a little later, they built or purchased the iron furnace and forge at Cartmel, intending to smelt the haematite ore of Furness with the peat moss which surrounded the furnace. In order to bring their moss to the furnace they dug a canal and transported it in an iron boat, the first the world had seen.

The attempts to smelt with peat were unsuccessful and they had to fall back on the wood charcoal, and continued their work with that.[1] Soon after this, John Wilkinson left his father, removed to the Midlands, and obtained work first at Wolverhampton, then at Bilston, where after ten years he succeeded in obtaining sufficient capital to enable him to build the first blast furnace ever constructed in Bilston, which he called "Bradley Furnace." Here he ultimately, after many failures, attained complete success in substituting mineral coal for wood charcoal in the smelting and puddling of iron ore. It is, however, certain that he owed more to his predecessors in the adjacent Coalbrookdale than he seems to have acknowledged.[2]

The history of the rise of Wilkinson is typical

[1] They invented the common box smoothing iron. J. Stockdale, *Annales Carmoelenses.*

[2] Dickinson, *op. cit.*, p. 7.

of one type of the capitalist class, which was evolving; he was shrewd, intelligent, and far from uneducated, pushed his snowball of capital hard and was not very scrupulous about what it picked up on its way. He used other people's ideas and was more of a strong, determined imitator than an inventor.

The iron works of Bersham, which Wilkinson subsequently took over, were of greater antiquity. Iron smelting had been localized there from 1699 in various hands and the foundry experimented with coal for smelting. In 1726 Mr. Lloyd, who then owned them, got into financial difficulties and disposed of his interest to a John Hawkins, who also found difficulty in remaining solvent, but with the assistance of his brother-in-law, Mr. Richard Ford, of Coalbrookdale, was in 1733 turning out nearly five tons of pigs per week.[1] Finally in 1753 most of the Bersham works came under the control of Isaac Wilkinson, and were worked by him with great profit. Nevertheless, the vast superstructure which his son John Wilkinson raised, rested more than has been acknowledged on the foundations which others, his predecessors, had laid, and other persons less energetic, but equally capable, had opened, by their sacrifices, the way which he and others were able to follow to their own great advantage.[2]

[1] A. N. Palmer, *John Wilkinson and the Old Bersham Iron Works*, 1899, pp. 41–2.

[2] A. N. Palmer, *op. cit.*, p. 43–4.

(3) *Tin-Mines*

Of our other mineral resources at this date there is no doubt that the tin and copper mines were the most important and the most interesting.

The Stannaries of Cornwall and Devon are constitutionally and economically different from the rest of the country.[1] When iron and steel were much less common than they are now, copper and tin articles were the obvious substitute, more so on the Continent than in England,[2] but even here copper was the common material for kitchen utensils and bronze the usual form of decorative metal work. Moreover, the tin mines are the reputed cause of the first entrance of these islands into the pages of written history, when the Phoenicians sailed round Spain to the Casseritides in search of tin. During the Middle Ages the continent of Europe seems to have drawn most of its supplies of tin from this country. The demand was stimulated, first by the introduction of bells into churches[3] in the sixth and seventh centuries, and secondly, by the use of

[1] The Stannaries had a court of special jurisdiction which was founded on an ancient privilege granted to the workers in tin mines to sue and be sued (in all matters arising within the Stannaries except pleas of life, land, or member) in their own court before a judge called the vice-warden of the Stannaries. 50 Ed. III, 16 Car., c 15.

[2] "The consumption of copper upon the Continent is greater (taking it house for house) than in England, as most of their household utensils and vessels are of brass or copper. A Com^{n}. Brazier in Brussels pays £2,000 per year for sheet copper." Boulton to Watt, March 26, 1782, Tew MSS.

[3] Hunt, R., *British Mining*, p. 45.

bronze cannon, which began about the end of the fourteenth century.[1]

The Duchy of Cornwall reverted to the Crown, soon after it had been granted by William the Conqueror, and it was thereafter retained in royal hands. During the years from 1175 to the reign of John, the output of tin, like other valuable possessions at that time, was engrossed by the Jews; Edward I made a grant to the tinners of Cornwall and Devon, who began to meet to concert their interests every seventh or eighth year on Hingston Hill, near Callington.[2]

Five towns in Cornwall and three in Devonshire were chosen where the ore was collected, a portion from each mine was retained by the Crown as regale and stamped. These towns were called coinage towns, and apart from this the tinners were allowed a free hand in selling their tin.[3]

After the expulsion of the Jews the mines were neglected, for with their removal few people were left capable of working them. The industry gradually regained strength, for only a very small number of workers were necessary for a primitive mine, and their tools were few and inexpensive. Thus the earliest mines were carried on by a number of

[1] *Ib.*, p. 46.

[2] *Ib.*, p. 48.

[3] An indenture of Ed. III dated 11 July Anno 32 grants "unto John Ballanter and Walter Bolbolter all his mines of Gold, Silver, and Copper in the county of Devon for two years with libertie to dig and search . . . and all other persons are excluded from digging there." Sir John Pettus, *Foedinae Regales.*

working partners, but hardly had these companies been formed when capitalism began to appear.[1] It became possible for a man to retain his share of the work by providing a substitute or his share of the cost of the undertaking. This system, which was a great boon to women and children, was called the "cost system," and was probably fairly well developed at the end of the fourteenth century, since there are references to mining shares being held by people who were not working shareholders.[2] In 1586 there were a variety of classes occupied in the mines; charcoal pedlars, who went from blowing-house to blowing-house with their packs, the blowers and the owners of the blowing-houses, who had become masters paying wages to workmen, the smiths, carpenters and others, who were employed about the mines, and finally the miners themselves.[3] These last were developing into two types—one, that worked for a wage and was very poor, and the other, composed of companies of miners adventuring in partnership. The mining adventurers were also drawn from different classes, first, there were the working miners, and second, the capitalists from outside, who were co-opted to work a lode, because the "charge amounteth mostly very high for any one man's purse, except lined beyond ordinary."[4]

[1] Lewis, *The Stannaries*, pp. 176–7.

[2] "'Abraham the Tinner' in 1357 is said to have owned two mine works and four stream works in which he employed 300 men, women, and children." *Ib.*, p. 189.

[3] *Ib.*, p. 198.

[4] *Ib.*, p. 199. Carew, *Survey of Cornwall*, p. 10.

The larger works were controlled by a captain and gradually the capitalist element became predominant. The expense and the uncertainty of the industry tended to cause this state of affairs; and though in small works the working partners still continued, their activities were more and more confined to the stream works and " deep and chargeable mines are carried on by persons of fortune or great skill.[1] Moreover, a complicated system of borrowing went on, which played into the hands of the tin merchants, who purchased the white or smelted tin after all the dues had been paid." These tin merchants were composed, in the sixteenth and seventeenth centuries, of a small group of London haberdashers, who were able, by their pressure on the shareholders immediately beneath them, to control all the workers in the mines. This position is paralleled in the Newcastle coal-fields, where the " hostmen," composed of dealers holding a monopoly of the trade, controlled the colliery lessees, and so through them the miners.[2]

It was at the end of the sixteenth century that a period of extraordinary depression occurred for the Stannaries. The shallow diggings to the stanniferous gravel were being worked out and shaft mining into the bed rock at greater depths was being pursued.[3] Even in the sixteenth century the depths at which they were working taxed to the uttermost

[1] Pryce, *Mineralogia Cornubiensis*, p. 173–4.

[2] Lewis, *op. cit.*, pp. 215–6.

[3] *Victoria County History, Cornwall*, p. 544. *Memoir of the Geological Survey*, Vol. I, p. 511.

the rude machines for drainage then in use, and in the reign of Charles I it is complained that the increased cost of drainage, added to the increased cost of materials, had brought about a period of great depression in the tin-mines[1]; and it was noted that both capital and labour were leaving mining for husbandry. The development of drainage in the tin-mines is important, as it is the immediate cause of the commercial success of the steam-engine which, in its turn, is the central fact of eighteenth century history.

In the earliest gravel or stream works the water was carried out in wooden bowls, or was carried off from the working in a "level" or trench leading from the work to the river. Later came the windlass turned by man-power, then small hand or force pumps, contemporary with which in the larger works was the adit. The adit was similar to the level only driven through the hill-side to meet the shaft at its foot. This last was expensive and temporary, because as soon as the shaft was driven deeper additional apparatus had to be used to raise the drainage to the level of the adit. Various mechanical pumping devices worked by man-power were also tried, but the severity of labour they entailed on the men working them[2] made them unsatisfactory and costly. Water wheels were used in some mines, but as their power was limited a

[1] *State Papers Domestic, Charles I.*

[2] A 4-inch pump drawing 20 feet employed from 20 to 24 men, working five or six at a time in six-hour spells. *Victoria County History, Cornwall*, p. 544.

deep mine needed two or three wheels one above the other to clear it effectively. In place of these combinations of wheels, John Costar, in 1710, successfully used a single large water-wheel to drain some of the deeper mines. His invention, however, was quite overshadowed by that of the steam-engine.[1] It is important to notice that a change had come over the tin-mining industry. The first shallow diggings had been worked by ordinary workmen with little or no capital, but as the mines became deeper, and other richer lodes were reached, the character of mining altered.[2] Larger capitals were required to sink the shafts, and keep them clear of water when the ore was reached. This meant the intervention of a new class of men outside the mining districts, or at any rate distinct from the ordinary miners, who were induced to venture their money in the mines. But at the end of the seventeenth century, owing to difficulties of drainage, one pit after another was being drowned out and the future of the industry seemed very precarious.

Many experiments had been made with steam-power, from Hero, of Alexandria, who lived more than a century before Christ, down to the romantic figure of the Marquis of Worcester. The problem of draining the mines was eventually solved by the use of steam-power, and the introduction and

[1] *Victoria County History, Cornwall*, p. 549. *Memoir of the Geological Survey of Great Britain*, p. 517.

[2] Smiles, *Boulton and Watt*, pp. 47–8, but query grant of Ed. III, quoted *supra*.

gradual improvement of the steam-engine is intimately connected with the progress of mining. Dionysius Papin,[1] who in 1687 was invited to fill the position of Professor of Mathematics in the University of Marburg, after many experiments with steam attempted to pump water by atmospheric pressure on a large scale. He was employed to erect machines on his principle to drain the mines of Auvergne and Westphalia, but the difficulty he experienced, in making and preserving a vacuum, rendered his enterprise abortive. His failure was probably due to the fact that, though a mathematician and physicist, he was not a mechanic.

The first working steam-engine was constructed in Devonshire by Thomas Savery. He was a clever engineer, and among other discoveries he made a paddle boat to move without wind. The fact that he lived in the midst of the Stannaries and that he knew the difficulty which the miners experienced in keeping the shafts clear of water, was probably the reason that led him to his next invention. He made a steam-engine in which the steam was alternately condensed in two vessels, causing a vacuum into which the water from the pit was actually sucked, thus avoiding any pumping apparatus. Savery avoids any exact account of the work of his engine[2], but there is no doubt that several of

[1] *Ib.*, p. 45. Papin described his engine for the Royal Society. *Philosophical Transactions*, Vol. I, p. 627.

[2] Smiles, *Boulton and Watt*, p. 51. *Philosophical Transactions*, Vol. I, p. 630.

his engines were erected in Cornwall about 1708–1714.[1]

The increase in the demand for coal had forced the Staffordshire coal mines to go deeper and deeper, and there, too, the drainage question had become of vital importance. Having come to an end of their resources in adits, rack and chain pumps, windlasses, etc., they were enthusiastic over Savery's invention. He was asked to erect an engine at the Broadwaters, near Wednesbury, but the strength of the water was too much for the engine with an ordinary boiler, and when the size of the boiler was increased, the steam pressure was too great for the weak material then in use and tore the engine to pieces.[2]

Savery probably erected his first engine at Hull Vor, near Helston, in Cornwall, and though it was an improvement on the methods of drainage then in use, it was dangerous and expensive. Later he erected engines in a coal mine in Staffordshire, and also at York Buildings, in London, to supply the west of London with water from the Thames; both of these were failures, and though various attempts were made to improve the engine, no advance was made till Newcomen and Calley took it in hand. Newcomen lived only fifteen miles from Savery and probably knew all about the experiments, and in 1705 he contrived a model which worked well. He had hit upon a combination of the ideas of Papin and Savery, and made the first

[1] *Victoria County History, Cornwall*, p. 549.
[2] Shaw, *History of Staffordshire*, Vol. I, pp. 85, 119.

steam-engine of the modern type.[1] The engine was not rapidly adopted in Cornwall, for in 1742 only one steam-engine was in use in the whole county.[2] However, in 1711, Newcomen and Calley offered to build an engine for the owners of a colliery at Griff, in Warwickshire, to drain their pits, which until then had been cleared by horse-power; but the colliery owners were not convinced of the practicability of the scheme until three years later. However, in 1712, Newcomen erected an engine to pump water from a mine at Wolverhampton, belonging to a Mr. Back. Most of this engine was built at Birmingham and taken to the mine, where it was erected. This worked badly at first, but by means of a leaking piston, it was discovered that the injection of cold water produced a more rapid vacuum and greatly improved the engine; while a lazy attendant discovered that the steam could be admitted, the cold water injected and the condensed water removed in turn by an arrangement of rods or strings, attached to the beam, and another step had been taken towards a self-acting machine.

Newcomen's next engines were erected in the

[1] The steam was generated in a separate boiler, from which it was conveyed into a vertical cylinder underneath a closely fitting piston which moved upwards and downwards. The piston was fixed to a rod, which was attached by a chain to a lever vibrating upon an axis, at the other end of which was the pump. Steam was let in under the piston, thus depressing the pump rod—the steam was condensed by surrounding the cylinder with cold water, a vacuum was produced and the pressure of the air forced the piston down, thus raising the pump rod.—Smiles, *Boulton and Watt*, p. 57.

[2] *Victoria County History, Cornwall*, p. 549.

north,[1] at Newcastle, where some colliery owners feared that the mines would be endangered by the proximity of the engine fires.[2] These engines were comparatively successful, and in 1720 he erected his first engine in Cornwall for Lemon, the manager of Wheal Fortune mine. Lemon was typical of many of the men then engaging in tin-mining. He rose from a mining boy to be manager of a tin smelting-house, and with the experience there gained he took charge of Wheal Fortune mine. With the help of Newcomen's engine he was successful, and having made a considerable sum he removed to Gwennap, whose mines he worked on a tremendous scale.

[1] Newcomen erected engines at :

1. Wolverhampton ..	Coal mine.	About 23 in. cylinder.
2. Coventry	,,	,, ,,
3. Newcastle-on-Tyne	,,	,, ,,
4. ,,	,,	,, ,,
5. Leeds (Austhorpe), 1714	,,	,, ,,
6. Wheal Fortune ..	Tin mine	(Pumps in two lifts, 9 in. bore, and drew 27 yds. at 15 strokes a minute. About 47 in. cylinder.)

[2] *The Compleat Collier, or the Whole Art of Sinking, Getting, and Working Coal Mines as used in the Northern Parts, especially about Sunderland and Newcastle*, by J. C., 1708 : " There is one invention of drawing water by fire which we hear of and perhaps doth to purpose in many places and circumstances, but in these collieries here a way, I am affraid there are not many dare venture of it because nature doth generally afford us too much sulpherous matter to bring more fire within these our deep bowels of the earth." For a detailed account of the whereabouts of the various Newcomen engines erected before 1775, when Watt finally went into partnership with Boulton, see *infra* pp. 148–51.

Newcomen's engines were quite successful, and enabled all the mines to go deeper than had been possible with earlier apparatus, but their great fault was their tremendous consumption of coal. Their use spread all over the country—Staffordshire, Yorkshire, Lancashire, and Northumberland all erected them, while in the thirty-six years from 1742 onwards sixty were erected in Cornwall. Here was a difficulty: in the north the engines were employed in pumping water out of coal-mines, where their large consumption of coal was not a vital question, but in Cornwall, where all the coal had to be carried long distances, and where the price of coal was high, it became difficult for the mines to show a margin of profit even though the Government allowed them a drawback of 4s. a chaldron on the coal they consumed.

Improvements in the engine were constantly being made, but though it became much more efficient by the developments of such men as Payne, Brindley, and Smeaton, the general principles remained unaltered, until Watt invented the separate condenser.[1]

(4) *Hardware*

In 1700 the hardware trade had already made its home in the Birmingham–Wolverhampton district.

[1] It is important to remember that the names mentioned in the text are only the comparatively successful ones. Many people tried to invent steam-engines. Even in 1674–5 there were three patents, one by Thomas Togood. *Calendar of State Papers, Domestic*, 1673–5, pp. 185, 607.

From a very early date Birmingham had been the centre of metal-working industries, and both Leland and Camden mention the smiths as being the most important and most interesting of the town's activities. In the sixteenth and seventeenth centuries, the smiths were content with the amount of trade that came to them, and they made no effort to look for work or to sell their products, for merchants came to Birmingham "with money in their saddle bags, took away the goods in exchange, or saw them packed ready for the next wagon before they left."[1]

Birmingham was not a chartered town, owing to its comparatively late start in the race of industrial progress, thus its development was entirely unfettered by craft companies;[2] and comfortable fortunes had been already amassed before the time of the Restoration, when a further impetus was given to the prosperity of the town by the influx of many dissenters. At least twelve nonconformist divines, in many cases with their adherents, came to Birmingham when the Clarendon Code closed the corporate towns to them in 1661.[3] Thus the qualities of thrift and industry which the nonconformists inculcated enabled them to accumulate savings which they devoted to building up large businesses on the solid foundations laid by the early metal workers.

[1] Smiles, *Boulton and Watt*, p. 161.

[2] *The Present State of Birmingham*, 1789, C. U. L., p. 16.

[3] *British Association Handbook, Birmingham*, 1913, Ashley, p. 354.

In fact, from 1600 onwards the progress of Birmingham was remarkably rapid, "no trade unions, no trade gilds, no companies existed, and every man was free to come and go, to found or to follow or to leave a trade, just as he chose."[1] In the new industries and new towns *laissez-faire* was an economic truth long before it was accepted as orthodox economic theory.

During the Civil War the town was for the Parliament, and when Prince Rupert attacked it, its industries were already so strong that the sword-works of a Mr. Porter furnished the Parliamentary army with 15,000 blades;[2] while in 1690 Birmingham goods compared favourably as regards quality and price with the best artistic productions of Milan.[3] At the end of the seventeenth century various new trades had been introduced into the town and buckles had become a very important article of manufacture. The proximity of the town to the growing coal and iron mines of Staffordshire, and its central position, aided the rapid extension of the hardware trades that were already localized round Birmingham. The Jacobite rebellion of 1745

[1] Timmins, *Birmingham Hardware District*, 1865, p. 211: "They (the representatives in London of the Birmingham Hardware Traders) are of no certain Company but every one chuses that he likes best and binds his lads accordingly as many other kinds of shopkeepers do." *General Description of All Trades*, 1747, p. 19.

[2] Timmins, *op. cit.*, p. 210.

[3] "Fine works of rock crystal, swords, heads of canes, snuff-boxes, and other fine works of steel" are described as seen at Milan, but with the further remark "they can be had better and cheaper at Birmingham." Timmins, *op. cit.*, p. 210.

gave a great stimulus to the Birmingham trade in guns, and this time the sword makers were less scrupulous than in the Civil War, and executed large orders for the Pretender's troops. That is the key-note of the century: economic motives are becoming more and more important, and those that, for want of better nomenclature, are called personal and political, have less and less power over the conduct of individuals and the policy of states.

Buckles were an important article of manufacture as long as they were fashionable, and even when they were going out of fashion efforts were made, and for a time with some success, to retain them as part of the clothing of an elegant gentleman. Even fashion, previously unfettered, was coming under the dominion of economic power. The beaux at the end of the eighteenth and the beginning of the nineteenth were the last of the old order and the beginning of the new. Their leaders were eccentrics and innovators, and the general crowd were ruled by what the tailors told them was fashionable.

However, buckles were a staple production of Birmingham. First made at Bilston, with the rise of the buckle to fashion, Birmingham supplied the whole demand for America, Holland, France, Germany, Italy, and Spain.[1]

The button was the enemy of the buckle, and a change in fashion and method of fastening took place about 1775. The earliest known maker of

[1] Timmins, *op. cit.*, p. 214.

buttons in Birmingham was one Baddeley, who invented the oval chuck, and he was followed by John Taylor, who was originally a cabinet-maker, and who became High Sheriff of Warwickshire in 1756. He introduced a number of improvements in gilt, plated, and lacquered buttons; the value of the weekly produce of buttons alone at his works was at one time estimated at not less than £800.[1]

The Birmingham smiths worked in all the metals. Brass work had been introduced into England in 1649 by two Germans, but after sinking £6,000 in their works at Esher and working them for thirty-four years, they were compelled to give them up "to their own ruin, and to the prejudice of the kingdom in losing so beneficial an art, having here, i.e. in England, the best copper and calamine in Europe."[2]

Birmingham obtained its copper largely from Bristol, where a works had been established by an ancestor of the Darbys of Coalbrookdale. At the beginning of the eighteenth century, Birmingham was working in silver as well. Thus, when at the end of the seventeenth century John Boulton, of Lichfield, fell upon evil days he sent his son, Matthew, to Birmingham, where he "became a silver stamper and piecer."[3] This son was Matthew Boulton, the elder, and his success in business was rapid. Matthew's son, also called Matthew, was born in 1728,

[1] Timmins, *op. cit.*, p. 434.
[2] *Ib.*, p. 234.
[3] Smiles, *Boulton and Watt*, p. 115.

and by the time he was seventeen was already a power in the firm, for he had invented the inlaid steel buckles which were soon to become so fashionable. These buckles were actually sent to France in large quantities, to be re-imported into England, as the latest French productions.

The younger Boulton soon became a partner and took almost complete control of the works. The business continued to prosper and Boulton set himself to raise the standard of his productions as high as possible :[1] an aim which had a beneficial effect on the industry as a whole.

In 1750 the Birmingham hardware trades were in a flourishing condition, numbering among their products " all sorts of tools, smaller utensils and toys in iron, steel, brass, etc." and " many thousands of artizans in different branches are constantly employed."[2]

[1] The type of goods supplied by the Birmingham Hardware Manufacturers is shown in an order for some goods passed on by Boulton and Fothergill to John Baskerville in 1771. It includes " Plate warmers, Candlesticks, Extinguishers, Inkstands, Tea-kettles, Coffee-pots, and Bread-baskets. This order was for Japanned goods and was to be supplied to " Mrs. Mary Stovins, Toy Shop Keeper, No. 139 in Cheapside, London." R. Strauss and R. R. Dent, *John Baskerville—A Memoir*, p. 103.

Boulton himself gives the materials he is prepared to work in writing to a correspondent in Rome. He says : " I should be glad to work for all Europe in things they may have occasion for in Gold, Silver, Copper, Plated, Gilt, Pinchbeck, Steel, Platina, Tortoiseshell."—Boulton to Wendler, July 10, 1767. Tew MSS.

[2] *A General Description of All Trades Digested in Alphabetical Order*. London, 1747, p. 18.

(5) *Pottery*

The earliest utensils in this country were made of wood, and it was not until the seventeenth century that there was any great demand for earthenware; a demand that at first was mainly supplied from abroad.

Delft, in Holland, was the great producer of earthenware, but the presence of good clay in Staffordshire had made it the home of pottery, and very early in the seventeenth century most of the varieties of earthenware in common use were made. The ware was of a very common description, mostly butter-pots, basins, jugs, porringers, and such like. However, the Staffordshire potters soon imitated the foreign ware and began to capture the home market. The industry centred in Burslem, with an offshoot in Hanley. In the parish of Burslem there settled about the year 1600 one Gilbert Wedgwood, and it is said that by the end of the seventeenth century one-third of the inhabitants bore this name.[1] Gilbert became the ancestor of a long line of potters who, however, increased their resources by other means.[2] In 1715, Thomas Wedgwood, the grandfather of Josiah, was a master potter, and a glance at the industry as it then stood is illuminating.

In a valuable document drawn up by Josiah in 1776 from original papers the following details are given:

[1] Smiles, *Josiah Wedgwood*, p. 7.

[2] Dr. Thos. Wedgwood at the end of the seventeenth century combined farming with pot-making while his son was innkeeper.

"Men necessary to make an oven of black and mottled, per week, and other expenses:

	£	s.	d.
3 men at 4s. per week and 3 at 6s.	1	10	0
4 boys at 1s. 3d.		5	0
1 cwt. 2 qrs. Lead Ore at 8s. ..		12	0
Manganese		3	0
Clay 2 cart loads at 2s.		4	0
Coals 48 Horse loads at 2d. ..		8	0
Carr[e] of do at 1½d. ..		6	0
Rent of works at £5 per annum ..		2	0
Wear and Tear of ovens, utensils, etc. £10 per annum ..		4	0
Straw for packing 3 Thraves of 24 sheaves to the thrave at 4d.		1	0
The Master's Profit besides 6s. for his labour		10	0
	£4	5	0"[1]

At this time (1710–15) there were in Burslem forty-three pot works, the largest output of which was £6 per week, and the total weekly output £139 10s., making a yearly total of £6,417.[2] More-

[1] E. Meteyard, *Life of Wedgwood*, Vol. I, p. 190: Wedgwood adds that "the wear and tear, Master's Profits, and some other things are rated too high; £4 per oven-full is thought to be sufficient or more than sufficient for the black and mottled works of the largest kind, upon an average as the above was a large one for those times."

[2] Forty-six weeks to the year. E. Meteyard, *Wedgwood*, p. 191.

over Burslem was so much the centre of the pottery industry that there were few pot works elsewhere.[1] Here then we have a small industry which, though it flourished on the Continent and was there organized as a craft gild,[2] never seems to have reached that state here. The probable explanation of this is that wooden platters for the very poor, and metal utensils of baser or richer metal for the wealthier classes, sufficed in days when road transport was so bad as to endanger any frailer vessels.

This suggestion is supported by the fact that though the pewterers,[3] silversmiths, and glassmakers[4] are mentioned in the Statute of Apprentices the potters are not included. Nevertheless, the trade seems to have imitated the organization of the rest of industry as a matter of convenience, for it was considered the normal thing to serve an apprenticeship of seven years as in other trades.[5] No large capital was as yet embarked in this trade, but it was free of all restrictions and was capable of easy expansion.

The state of the roads made progress difficult in an industry whose product was so fragile. Wedgwood himself, describing the state of things in 1715, said " only one horse and one mule kept at Hanley.

[1] *Ib.*, p. 192. There were only seven potters at Hanley and two at Stoke.

[2] Potters of Paris, 1456. Unwin *Industrial Organisation*, p. 46.

[3] 5 *Eliz.*, Cap IV, 2.

[4] 5 *Eliz.*, Cap IV, 5.

[5] Aaron Wood was apprenticed to Dr. Thos. Wedgwood in 1731 for seven years. When his apprenticeship expired he was engaged for five years as a journeyman at five shillings a week.

No carts scarcely in the Country. Coals carried on men's backs. Hanley Green like Wolstanton Marsh."

The general state of the pottery districts was bad; the houses of the workers were thatched hovels, sometimes covered with mud, everything was coarse and unwholesome. Ale-houses abounded, and it was the ale-houses that were the best customers for earthenware. Bull and bear-baiting continued right down to the opening of the nineteenth century.[1] Wesley was stoned at Burslem when he preached in 1760.[2]

The usual pot work was carried on by a man and a labourer, or a man and his family. The son dug the clay, the man fashioned and fired the ware, mother and daughters filled the panniers on the horse's back. The potters themselves then travelled with their pack-horses through the country to fairs and markets to sell the products of their toil. The pot-fairs of to-day remind us of the infancy of this industry. It is easy to see that an industry of this type would naturally and easily increase in size with an improvement in transport and a development of demand.

In pottery, as in many other industries, we owe much to the immigration and knowledge of foreigners. The most momentous innovation of the seventeenth century was the introduction of the salt glaze by two brothers called Eler, who followed the Prince of Orange from Delft. They produced fine red and black ware, more delicate in execution

[1] Smiles, *Wedgwood*, p. 11, 12.
[2] *Wesley's Journal*, *March* 9, 1760, Vol. IV, p. 370.

and better in glaze than the native product. They conducted their works with great secrecy; idiots were employed at the thrower's wheel in preference to normal workmen. These precautions excited the curiosity of the Burslem potters. Anything was justifiable against foreigners, and a man called Astbury, pretending to be an idiot, obtained employment and worked with the Elers for two years, and discovered all their secrets. Another potter called Twyford also obtained the same knowledge. Both set up pot works of their own. Astbury was the more successful and made frequent journeys to London, where he sold his ware and obtained further orders. The Elers, disgusted with the treatment they had received, left Burslem for London, where they connected themselves with a firm of Venetian Glass Makers, and remained the best potters in England till Josiah Wedgwood displaced them. Astbury did much for the pottery industry, his inventions include the use of flint in white-ware and other improvements, while in enlarging the market he rendered yeomen service to the growing trade.

(6) *Salt Manufacture*

The salt-mines of England had been worked from Roman times, but it seems that during the Tudor period we were content with French and German supplies. However, in the reign of Elizabeth, Cecil tried to persuade Germans to come to England, and by his efforts the industry was naturalized in England. A monopoly was granted to the immi-

grants for salt-mining only, for many of the Queen's subjects made salt from brine.[1] In the first volume of the *Philosophical Transactions* there is a communication from Dr. Wm. Jackson which recommends Cheshire salt as superior to French salt, and gives a careful account of the methods used.[2] In Cheshire, salt had been made from brine in small quantities for centuries and the manufacture gradually increased, most of the salt-houses being attached to noblemen's houses. A great increase in output occurred when the beds of rock salt were discovered in 1670. In 1675 it was estimated that 26,927 tons of salt were manufactured in Cheshire every year. The most important advance which this industry made in the eighteenth century was due to the improvement in transport in 1721, when the river Weaver was made navigable.[3] Like the pottery trade, improvements in transport and increases in demand were all that were needed for rapid development.

The second centre of the salt industry was in Durham, where at Shields brine from the sea was converted into salt as early as 1489. In 1635 a company was formed for the production of salt, and

[1] *State Papers, Domestic, Eliz.*, XXVIII, 5.

[2] *Philosophical Transactions*, Vol. I, p. 355.

[3] *Memoirs of the Manchester Literary and Philosophical Society*, 1884, p. 18–19: "The salt trade is generally acknowledged to have been the nursing mother and to have contributed more to the first rise, gradual increase, and present flourishing state of the Town of Liverpool than any other article of commerce." *Holt and Gregson MSS.* Vol. X, p. 253, Liverpool Municipal Reference Library.

the importation of salt from the Bay of Biscay was forbidden by Parliament.[1] Neither this grant nor that of Cecil to the Germans was dictated purely by a desire to encourage industrial expansion. Cecil wished to use the mineral resources of England with the assistance of aliens, if necessary, to supply ordnance for national defence, while Charles I was making grants with an eye to possible revenue.

An interesting account of the salt manufacture in 1635 is given by Sir Wm. Brereton, Bart. He says that the pans "yield every of them every draught two bowls which is worth 2s. a bowl and sometimes 2s. 4d., so every pan yielding every day four bowls at two draughts which comes to 8s. all twelve pans are worth every day £4 16s.; so as all the twelve pans in a week make salt worth £28 a week; which in the year amounts into £1,400."[2]

This speaks of a firmly established industry. He goes on to say that the two men who clear away the ashes are paid 14s. per week besides the man who pumps the brine. Apparently or naturally only coal was used in the evaporation.[3]

Moreover, there was a "domestic" salt industry, or possibly, rather a collection of small masters; there were in Shields about two hundred and fifty houses "poor ones and low built, but all covered

[1] Cunningham, *Industry and Commerce*, Vol. II, p. 289.

[2] Sir Wm. Brereton, *Notes of a Journey through Durham and Northumberland in the year* 1635, p. 21.

[3] "Here at the Shields are the vastest salt works I have ever seen, and by reason of the conveniency of coal and the cheapness thereof, being at 7s. a chaldron, which is three weeks' load," *Ib.*, p. 22.

with boards. Here in every house is erected one fair great pan." Each of these pans "cost about £100, and cannot be taken down with less than £10 charge." These also made a handsome profit of about £2 10s. per week.[1]

There is some little doubt as to the exact organization of this industry, but in 1700 the pans were probably the property of the landed families in the neighbourhood. Shields salt was the most celebrated salt in the kingdom, and was produced in such quantities in South Shields as to give a character and even names to the districts of the town.[2]

[1] "Every pan yields four draughts of salt a week and every draught worth about £1 10s. spent in coal: ten chaldron of coal at 7s. a chaldron which amounts to £3 10s. in coals, deduct out of £6 there remains £2 10s. besides one man's wages." *Ib.*, p. 24.

[2] "This trade was carried on by several of the most wealthy families in this neighbourhood in the beginning of the last century, and about 200 pans were employed in producing salt, which was extracted from sea-water and brine springs. The production of salt from sea-water in this locality has given place to that obtained from the brine springs and rock salt of Cheshire." —*Industrial Resources of Tyne, Wear, and Tees*, p. 160.

CHAPTER III

Capital and Labour, 1700–1750

(1) *Population : The Growth of the Proletariat*

If we are to consider the development of the economic structure of England, one of the first main points of interest is the number of the people.

In 1696 Gregory King estimated the population of England and Wales at 5,500,520 : and though it is impossible to ascertain the number with perfect accuracy this estimate may be assumed to be approximately correct, being supported by a Government inquiry of the same date[1] and modern statistical study, both of which place the population in 1696 at five million, two hundred thousand. Further, basing his calculations on the amount of wheat produced, Thorold Rogers estimates that the population was a little over five millions,[2] calculating that the population had only increased by a million during the seventeenth century, and chiefly in the north, which was farthest away from the

[1] Arnold Toynbee, *Industrial Revolution*, p. 8. Macaulay, *History of England*, pp. 219–221.

[2] Thorold Rogers, *Economic Interpretation of History*, 1909, seventh ed., p. 158.

districts troubled by civil war.[1] This very feeble increase in the population was probably due to the very large death-rate[2] which, in turn, was the result of bad sanitation and an erratic and insufficient food supply. Famine and disease were indissolubly connected, and the death-rate in many parts of the country exceeded the birth-rate. Moreover, the rigid mediaeval system, which tied a labourer down to the place in which he was born and prevented him from getting married without the consent of his overlord, had only just disappeared, when the Government interfered to restrain the supply of population from adjusting itself in answer to the demand in various parts of the kingdom. The Law of Settlement made it difficult for people to move about the country. As it was usually necessary for a newly married couple to have a house of their own, marriages were restricted by the supply of houses, and farmers and landlords went so far as to destroy cottages in order to prevent the settling of people who might become a charge upon the parish. This was especially true of rural districts, for the agricultural population remained almost stationary in the hundred years from 1660–1760.[3] Moreover, the manufactures of the country had not yet begun to absorb large numbers of the people, though the rise in the population of the

[1] *Ib.*, p. 159.

[2] Leroy Beaulieu, *La Question de la Population*, p. 3.

[3] Marshall, *Principles*, pp. 187, 188. *First Report of Poor Law Commissioners* [1835], p. 303. Middlesex rose from 624,200 in 1700 to 641,500 in 1750. The East Riding of Yorkshire fell from 96,000 to 85,500.

county of Lancaster from 1700 to 1750 from 106,200 to 297,400, and in the West Riding of Yorkshire from 236,700 to 361,500,[1] shows that the movement of population to the north had already started.

The growth of a large proletariat was essential if there was to be any great development of industry on a capitalist basis,[2] and as a large increase of population did occur in England during the eighteenth century, there must have been limiting factors operating in 1700 which were removed easily and rapidly as the century progressed. Chief among these limiting factors had been the poor food supply. The rapid improvement in the methods of agriculture and the developments of transport, levelling up inequalities of distribution did much to remove this obstacle.[3]

The improvement of communication that took place as the century went on played a very large part in the increase of population, resulting in the adjustment of inequalities of sex distribution and of supply and demand for labour. The population was only increasing slowly, and though the

[1] *First Report of the Poor Law Commissioners*, 1835, p. 303.

[2] J. A. Hobson, *Evolution of Modern Capitalism*, p. 2.

[3] "The consumption of the Growth of Grain as well as of the inexhaustible stores of Fuel which nature has lavished upon particular parts of our Island, was limited to the neighbourhood of those parts of our Island which produced them," and now we are "released from treading the cautious steps of our forefathers. The mutual Blessings of the Island are shared by the inhabitants with a more equal hand."—Homer, *An Inquiry into the Means of Preserving the Public Roads*, 1767, p. 4.

enclosure movement had already produced a considerable number of "rogues and vagabonds," yet until the middle of the eighteenth century the great majority of the village industrial workers still retained rights on the common land. They were not the pure proletariat that is identical with the wage-earning class of modern capitalism. The increase of enclosure, though it caused immediate hardship to many small landowners, was in the long run, in so far as it encouraged and made possible improvements in agriculture, a factor in the increase of population. The enclosure movement, then, may be said to have partly made the wage-earning class by separating the workers from their land, and by supplying them with more food as they increased in numbers.

(2) *The Economic Position of Labour*

Under the gild organization there had developed merchants, shopkeepers, large and small masters, and journeymen. In the non-textile trades, before 1750, this result as yet was still in the process of evolution. In the trades that we have taken, pottery, hardware, and mining, the most clearly defined class were the journeymen; both in their status and in their economic relationship they approximated to the wage-earning class of which they formed a nucleus.

In 1715 a potter in Burslem was paid 4s. to 6s. a week.[1] In the salt works of South Shields, a work-

[1] E. Meteyard, *Wedgwood*, Vol. I, p. 190.

man received 7s. a week.[1] While in the coal-mines of Durham, hewers were paid "12 pence per score corves," each corve holding 14 or 15 pecks.[2] In the same mine barrowmen got 20 pence or 22 pence a day,[3] a rate of remuneration which worked out at about 10s. per week.

A definite wage-earning class existed, and it was only the fact that most men had a holding of land that prevented the wage-earning class being largely added to, and the enclosures of the eighteenth century largely increased the numbers of the wage-earning class. From the beginning there were always intermediate classes between the wage earner and the large controlling capitalist; thus in the study of development we are mainly interested in the capitalist at the top. He is the man who develops, and on his progress or failure depends the growth of the industry he controls. The industries where the biggest gulf existed between capitalist and wage earner were those in which there was the widest gap between day wages and the initial capital necessary to set up in the trade as a master.

In a *Description of all Trades* (1747), the largest amount of capital required to set up in any trade is that in the Birmingham Hardware Trade, where the journeymen made £20 a year, while "at least £500 was necessary to set a man up; and one that

[1] *Journey through Durham and Northumberland*, 1635, p. 22.

[2] *The Compleat Collier*, p. 29.

[3] *Ib.*, p. 36.

intends to pursue business with spirit can use £2,000."[1]

The division of labour was already consciously developed; the blacksmiths in 1747 were divided up into thirteen different and specialized trades, and the whole of the production of many of them was sold by ironmongers.[2]

Industries were becoming attractive, not so much because they were profitable from the point of view of the capitalist, but because they paid good journeymen's wages.

Some industries took no apprentices except the poorer sort, "Fatherless Children, Parish Apprentices, and Hospital Boys, which are put to the most

[1] *Description of All Trades*, 1747. The details of the following trades are interesting:

Business.	Journeyman's Wage.	Capital necessary to begin as a Master
Apothecaries, p. 3 .	£10 to £40 and board .	£100 to £200
Bakers, p. 11 ..	7s. or 8s. a week and board	£100
Birmingham Hardware, p. 18	£20 to £30 and board	£500 to £2,000
Brewing, p. 34 ..	£50 to £200	Many thousands
Brick Maker, p. 38	4s. or 5s. a day (a fine weather occupation)	£500
Fire-Engine Makers,	.. ..	£500
Potters, pp. 172–3.	.. ..	£1,000

Twice as much capital was considered necessary for potteries than for fire-engine building.

[2] *Ib.*, pp. 20–22.

slavish part of our Business,"[1] the most noteworthy of these were the brewers and the hardware trades. Apprentices were taken with a view to becoming wage earners where they had no longer any aims at mastership. The distance between the classes was widening, though the means of crossing the gap were still easily available.

(3) *Capital*, 1700–1750 : *The Growth of Wealth*

In the Middle Ages, England was very ill-supplied with capital; religion, warfare, or pleasure, providing the most noteworthy capitalist enterprises. Nevertheless, in historical times there were many ventures that needed wealth to some small extent, especially those connected with transport. The shipping industry had always required capital, and, for many centuries, it was the traders who used their surplus funds most productively.

The application of capital to industry was a very gradual process; a few tools and a small supply of raw material sufficing in most cases. The larger industrial enterprises were for centuries quite undeveloped owing to lack of capital. The monks, in the ninth century, were the first to turn their attention to the coal-mines,[2] just as they were the earliest scientific farmers. However, their place, both in agriculture and mining, was being taken, at the end of the seventeenth century,

[1] Boulton to Peter Bottom, March 30, 1768. Tew MSS.

[2] R. Meade, *The Coal and Iron Industries of the United Kingdom*, 1882, p. 1.

by the great landowners. Apart from shipping, mining, and some little inland transport, there was comparatively little invested capital in the year 1700;[1] in fact, the total sum of capital in England, at that date, was ridiculously small.

A careful study of the growth of capital was made by Giffen,[2] in 1889. He bases his earliest estimate upon that of Sir Wm. Petty, who deduced the national capital from the national income in 1679. In this estimate the total income is given as £40 million, and this is capitalized at £250 million. The amount is divided as follows:

	Income	Capital
Land	£8 million	£144 million
Houses	£2½ „	£30 „
Shipping	—	£3 „
Stock of Cattle	—	£36 „
Coined gold and silver	—	£6 „
Wares, merchandise, plate, and furniture..	—	£31 „
Income from above sources exclusive of land and houses; and from personal sources	£29½ „	—
	£40 million	£250 million[3]

This estimate is confirmed by that of Gregory King and Davenant concerning the year 1688. Their estimate is £320 million, but this is the result of their having placed a higher value on the rental

[1] Scott, *Early History of Joint-Stock Companies to* 1720, Vol. I, pp. 335–6.

[2] Giffen, *Growth of Capital*, 1889, p. 74.

[3] *Ib.*, p. 80.

of land, and having capitalized it at eighteen years' purchase, instead of twelve, as Petty did. The value of the rest of the nation's capital, that is without agriculture, is given by Sir William Petty as £106 million, and by Gregory King as £86 million, thus, an average estimate of the fixed and trading capital of this country in 1700 would put it at about £100 million.

But, though it is necessary to know the total amount of capital, and its distribution is the key to later industrial development, yet there is another and more important point. The eighteenth century is a century of rapid expansion, and, of course, expansion in capitalist enterprise can only take place when each year shows a surplus of income over expenditure unconsumed. It has been suggested that, though Petty included the income from houses in his estimates, yet he did not include the rent from them; an item, which Prof. Scott estimates at £1½ million, and, as Petty's estimates of national expenditure and income previously balanced, this item would make the annual balance added to the national capital about £1½ million too.[1] This deduction, by itself, would be inconclusive, but Gregory King has estimated that the annual increment of stock in 1664 was only about £1¼ million. Thus, it is obvious that the rate at which capital, and consequently industrial and commercial enterprise, was increasing at the end of the seventeenth century was slow, and it was only when the mineral wealth of the country was developed with the aid

[1] Scott, *op. cit.*, Vol. I, p. 265.

of the steam-engine that capital began to increase rapidly. These two things, the development of steam-power and the accumulation of capital, are inextricably bound together, and their stories cannot be separated.

The increase of capital in 1700, then, was about £1½ million annually, and the industrial and commercial capital about £100 million.

The allocation of this capital to the various trades and industries of the country, is a task of extreme difficulty. At the beginning of the eighteenth century, the weight of the wars of William III and Anne was still heavy[1]; for by the financial expedient of a National Debt, payment had been spread over the future, and, consequently, there was a general increase in taxation. Ministers found this by taxing industry and trade; it is, therefore, impossible to find accuracy in any trade pamphlet of 1700–50. Such pamphlets were meant as propaganda to protect an industry from the hands of the rapacious tax gatherer, either by emphasizing its importance and the number of people whose welfare was bound up in its success, or by minimizing its size and profitableness, and pointing out that the yield of a tax upon it would hardly balance the expenses of collection.[2]

For these reasons, it is hard to tell which were the wealthy trades in the interval between the decay of the gilds and the beginning of modern capitalism. Hence it is necessary to take industry

[1] Kennedy, *English Taxation (1640–1799)*, pp. 96–7.
[2] *Social England*, Vol. V, ed. Traill, p. 162.

by industry, estimating the number and class of the people engaged, the amount of capital invested, and the volume and value of the resulting product.

(4) *The Employment of Capital*

In all those industries that we have sketched, coal-mining, iron-working, tin-mining, hardware, pottery, and salt manufacture, the capital was supplied by one or two men; and the new joint-stock principle had little or no influence, except in the mines, where it was the result of a different set of causes, and had evolved independently of the main movement. There were, indeed, in 1700, one or two companies of an industrial nature capitalized by joint-stock methods, among which were a glass-making company, a company for "making iron with pit-coal," and, in Scotland, "the Glasgow Soaperie, the Glasgow Sugarie, and the Paper Manufactures."[1] These were the exceptions—the iron trade, and the potteries, the hardware trade, and brewing, all owe their development to the energy of isolated men.

As for the joint-stock companies, Adam Smith's dictum, though perhaps unfair in its criticism of their methods, is, nevertheless, historically true of the position as he saw it. He says, "The only trades which it seems possible for a joint-stock company to carry on successfully without an exclusive privilege are those of which all the operations are capable of being reduced to what is called a

[1] Scott, *op. cit.*, pp. 335–6.

routine, or to such an uniformity of method as admits of little or no variation. Of this kind is, first, the banking trade; secondly, the trade of insurance from fire, and from sea risk, and capture in time of war; thirdly, the trade of making and maintaining a navigable cut or canal; and, fourthly, the similar trade of bringing water for the supply of a great city."[1]

Thus, in 1750, we have the old established industries, like the textiles, gradually developing and emancipating themselves from gild organization, by an increase in capital and in the amount of produce, but employing very large numbers in order to supply the demand of their markets. In the mines, the same difficulty of supplying the demand was also met, but in this case it was due to lack of power to pump the water out. In the iron trade, the wood supply was no longer adequate to supply the demand for charcoal for smelting; recourse was had to coal, but there, again, more power was needed to drive the bellows, in order to produce the increased blast necessary for smelting with coal.

In the undertakings that Adam Smith described as possible for joint-stock enterprise, more power was also needed; pumping engines were necessary to supply a town with water, as well as to keep the water in a canal at its right height all along its course. The enclosures had released or forced out of agriculture large numbers of moneyless men, while the country, by its long freedom from

[1] Adam Smith, *Wealth of Nations*, Vol. II, p. 242.

invasion, had had time to acquire a sound financial position that made accumulation of capital easy. Moreover, at this date, we were fortunate in having men who possessed those constructive ideas that are the most important part of capital. The importance of the constructive thoughts of men like Boulton, Watt, Wilkinson, Wedgwood, and Whitbread, cannot be overestimated.[1]

The most important was Watt. The history of his invention, its capitalization and its connexion with the development of other industries, is the kernel of the story of the Industrial Revolution

(5) *Banking*, 1750

As we have noticed, it is possible for people in various parts of the country to be producing a surplus, and yet that surplus, if there is no means of applying it in other parts of the country where it will be used productively, will go to waste. Until the end of the seventeenth century much of the country's surplus did go to waste. The only part that was used productively was that part in the possession of people who were prepared to risk what they already had in order to get more. It was

[1] Marshall, *Principles of Economics*, p. 780: "The world's material wealth would quickly be replaced if it were destroyed, but the ideas by which it was made were retained. If, however, the ideas were lost, but not the material wealth, then that would dwindle and the world would go back to poverty, and most of our knowledge of mere fact could quickly be recovered if it were lost, but the constructive ideas of thought remained, while if the ideas perished the world would enter again on the Dark Ages."

almost impossible for a man who had " constructive ideas " to get them carried out, unless he had money as well. The tendency of the seventeenth century, was towards a more productive use of surplus. The development of joint-stock enterprises from the regulated companies, the flotation of a National Debt, and the beginning of a trade in annuities, all helped to bring treasure and the capital it represented into the hands of men who could apply it.

The goldsmiths had been accustomed to lend money in coins or bills which represented bullion actually in their possession, but even this accommodation was given chiefly to foreign trade. Defoe, in 1697, complained of the " fair pretences of fine Discoveries, new Inventions, Engines," that were persuading the people to invest their money. Among the new nothings he numbers, " Linen-Manufacturers, Salt-peter works, Copper mines, Diving Engines, Dipping, and the like."[1]

Even the advocates of a bank were zealous, chiefly because they saw how lack of the means of obtaining capital hampered foreign trade.[2] Banks " will furnish many young men with stock that have, by their industry and well spent time and travels in their apprenticeships, gained good experience in traffic, but when they are come to be for

[1] Defoe, *Essay on Projects*, pp. 11–13.

[2] Thorold Rogers, *Industrial and Commercial History of England*, p. 70 : " Credit is this power which a State or a person has of attracting to itself or himself wealth either in the passive or active form from other persons or other States." " Loans or credits obtained by mercantile persons precede historically those obtained by non-traders."

themselves wanting stock, friends, or credit to begin to trade with, are thereby much discouraged."[1]

The dislocation of trade that followed the Great Fire of London, and the Dutch war in 1665–7, caused a great scarcity of capital, and various schemes were mooted for the establishment of some credit organization. In 1665, it was proposed to set up an Office of Credit to make advances to traders up to three-quarters of their goods, while in the following year an issue of inconvertible paper money, based on the Crown lands, was suggested.[2]

The revival of industrial activity in 1676 resulted in the practical accomplishment of some of these schemes, and in the elaboration of several new ones.[3] Thus, throughout the last quarter of the seventeenth century, there was an increasing demand for banking facilities.

This obvious need of a banking system, and the known example of the Dutch, soon had a result in England, and, " before the end of the reign of Charles II, a new mode of paying and receiving money had come into fashion among the merchants of the capital. A class of agents arose, whose office

[1] Lambe, *Somers Tracts*, VI, p. 456.

[2] Scott, *Joint-Stock Companies to* 1720, p. 280. This Office of Credit, which was to be " neither a bank nor a Lumbard," was definitely proposed for the benefit of the mercantile community.

[3] *Ib.*, p. 293. An office for the discount of mercantile bills was already working, though it was objected to on the ground that such an institution, " having no fund, anchorage, and secure foundation," would come to nothing.

it was to keep the cash of the commercial houses ;"[1] and in 1694 the Bank of England was established. In 1695 the Bank of Scotland received a similar monopolistic charter.[2] However, its privilege lapsed in 1716 and no renewal was sought for. In 1727 the Royal Bank of Scotland was founded and the line of Scotch development was in the direction of large national joint-stock banks, while England kept one large national monopolistic bank and numbers of private banking houses. The disadvantage of the latter system was that in times of financial crises[3] many of the smaller houses failed.

The disadvantage that both countries shared was the restriction of banking systems to the capitals of the two countries.[4] In England in 1750 the "Bristol Old Bank" was the only bank outside London.

Moreover, the banks also advanced money for the purposes of speculation, and in the early part of the eighteenth century much capital was thus wasted that might have helped to fertilize the provinces.[5]

It was, however, possible in 1750 to obtain credit, and, by means of credit, for wealth belonging to one class of people to be productively

[1] Macaulay, *History of England*, Vol. III, p. 289.

[2] Graham, *One Pound Note*, p. 11. The noticeable thing about this national joint-stock bank was the distribution of the stock; the shareholders were to be not less than 60 nor more than 1,200.

[3] *Ib.*, p. 99.

[4] *Ib.*, p. 96. L. Grindon, *Manchester Banks and Bankers*, p. 2.

[5] Graham, *op. cit.*, p. 76. Cunningham, *op. cit.*, Vol. II, p. 447.

employed by another class. In England there was plenty of capital and it easily became available through the private banking houses. In Scotland, however, the backward nature of the country made capital scarce. What existed was mainly gained by foreign trade.[1] From 1700 onwards, the new methods in farming were introduced, and many expensive mistakes were made by the proprietors.

From 1765, there were ten years of bad harvests, while along with the agricultural improvements came innumerable sanguine schemes for reclaiming land, building roads and bridges, and opening manufactories of all sorts. Some of the promoters were wealthy, many were not; all were hopeful, none had experience. Moreover, the wild speculation that was going on had made the exchange with London more and more adverse, and defeated its own ends by compelling the banks to restrict credits in order to reduce their note circulation, which was being used by bullion dealers to draw away coin to London.[2]

Thus, at the beginning of the second half of the century, the expectations of the advocates of a banking system had not been fulfilled in Scotland. For the new trades which had opened, and the new industrial facilities which the credit system offered, were used so widely by the general public that had

[1] John M'Ure, *History of Glasgow* (1736), p. 168–9: "There are Merchant travellers betwixt Scotland and England many of whom became sea adventurers afterwards. The Scots pedlers in England appear to have been very numerous."

[2] Graham, *op. cit.*, p. 107.

money to invest,[1] that a natural restriction of credit and a general suspicion of large and risky undertakings had become the general policy of the banks.

This was the financial position when Watt turned his attention to the steam-engine.

[1] *Social England*, Vol. V, p. 157. The estates confiscated in 1745 were taken over by the York Buildings Co., originally established in 1675 to supply Piccadilly and St. James' Fields with water, but all that the Company did was to introduce a few industries to a languid existence and fill the pockets of the Edinburgh lawyers by means of a rich crop of litigation.

CHAPTER IV

The Invention of the Steam-Engine

(1) *Watt's Early Inventions*

James Watt, the grandson of a teacher of mathematics, and the son of a shipwright merchant, of Greenock, was born in 1736. On the advice of a Glasgow Professor, he was sent to London in 1755 to be apprenticed to a mathematical instrument maker.[1] However, on arriving in London, he discovered that the seven years' apprenticeship rule of the gild was largely insisted upon, and it was only with difficulty that he could find any one who would take him for so short a time as a year. This was finally arranged, and a Mr. Morgan was to give him a year's instruction for twenty guineas.[2]

His stay in London was characterized by great frugality and occasional fears of the press-gang. In a letter to his father, he writes: "They now press anybody they can get, landsmen as well as seamen, except it be in the liberties of the city, where they are obliged to carry them before my Lord Mayor first; and, unless one be either a 'prentice or a creditable tradesman, there is scarce any getting off again, and if I was carried before my Lord

[1] Muirhead, *Life of Watt*, pp. 34–5.
[2] *Ib.*, p. 36.

Mayor, I durst not avow that I wrought in the City, it being against their laws for any unfreeman to work, even as a journeyman, within the liberties."[1]

When Watt had completed his training, he returned to Glasgow to set up in business for himself, only to be met by the same restrictions that existed in London ; the gilds were still struggling to retain their control of the trade of the chartered towns,[2] and as Watt was neither the son of a burgess nor the husband of the daughter of one, and not having served a regular apprenticeship, he was refused permission to open his shop. Watt's early friendship with the Glasgow professors now stood him in good stead. He was made mathematical instrument maker to the University, and given a shop within its walls, where he carried on his trade. Even in this small venture Watt lacked capital, and took one John Craig into partnership, the details of which give an insight into the scale of a small business in 1750, and the relatively small part fixed capital played. The journal of the partnership begins with the following entry : " An Inventory of tools, goods, etc., belonging to us, James Watt and John Craig, each one-half. Taken October

[1] Watt to his father from London, March 31, 1756, quoted Muirhead, *op. cit.*, p. 39.

[2] *Extracts from the Records of the Merchants Adventurers of Newcastle-on-Tyne*, Surtees Society, Vol. XCIII, p. xlv. : " During the 18th Century various people were restrained from trading in the town who were not free of the merchants' company." Among the prosecuted were Grocers, Joiners, Printers, Barbers, Slaters, Saddlers, and Smiths. Twelve cases in all from 1735 to the last in 1775.

7th, 1759, at Glasgow," and then enumerates a variety of mechanical tools from a turning lathe to a flatting mill, with philosophical instruments, chiefly mathematical and optical, the whole to the value of which £91 19s. 3½d., with cash on hand, £108 8½d., made the total capital £200.[1]

During the period dealt with in the journal, 1759–1765, the ready money sales brought in about £50 per month, or £600 per annum, a large portion of which went to pay wages and buy materials. Watt, himself, is credited with a salary of £35 per annum, rather more than twice the wage of a potter, and rather less than twice that of a miner. From employing one journeyman and occasional extra help, the business expanded so that in 1764 Watt employed sixteen men of various capacities.

In 1763, Watt left his rooms in the University, and in July of the following year married his cousin, Miss Miller. During this time, too, Watt made the acquaintance of Professors Black and Robison, of Glasgow University.

During his stay in the University, Watt looked after the mathematical instruments which belonged to it, and, " in the winter of 1763–4, having occasion to repair a model of Newcomen's engine, belonging to the Natural Philosophy class," his mind was again directed to the study of the steam-engine.[2]

He repaired it, but upon its being set to work,

[1] Muirhead, *op. cit.*, p. 44–5.

[2] Watt's own account in his notes on Robison quoted by Muirhead, p. 75. He made some earlier experiments with Papins Digester in 1761.

it was discovered that it would only go a few strokes at a time, though the boiler was big enough to keep it well supplied with steam. The large amount of water that it was necessary to inject to condense the steam, put Watt on the track of the theory of latent heat, which Dr. Black had already discovered.

Upon thinking the matter over, Watt saw that there was a great wastage of steam and power through the alternate heating and cooling of the cylinder, and, upon reflecting further, he perceived "that in order to make the best use of steam, it was necessary—first, that the cylinder should be maintained always as hot as the steam which entered it; and, secondly, that when the steam was condensed, the water of which it was composed, and the injection itself, should be cooled down to a 100 degrees, or lower where it was possible. The means of accomplishing these points did not immediately present themselves; but early in 1765 it occurred to me that if a communication were opened between a cylinder containing steam and another vessel, which was exhausted of air and other fluids, the steam, as an elastic fluid, would immediately rush into the empty vessel, and continue to do so until it had established an equilibrium; and if that vessel were kept very cool by an injection, or otherwise, more steam would continue to enter until the whole was condensed. But both the vessels being exhausted, or nearly so, how were the injection water, the air which would enter with it, and the condensed steam, to be got out?" This was

eventually solved "by employing a pump or pumps to extract both the air and the water, which would be applicable in all places, and essential in those cases where there was no well or pit."[1]

This is Watt's great discovery—the theory of separate condensation, it made the steam-engine a useful and economical source of power, and was so successful, that for a hundred years after his invention no drastic alterations were made in the type of steam-engines in common use. Following naturally from the main discovery were these corollaries. The piston in Newcomen's engine was kept air-tight by a supply of cold water on its upper surface; this was no longer possible, and Watt was forced to use "oils, wax, resinous bodies, fat of animals, quick-silver, and other metals in their fluid state."[2]

Again, the cylinder being open, the air which entered to press down the piston in the old atmospheric engine would cool the cylinder. Therefore, he proposed to close the head of the cylinder, and to allow the piston rod to slide through a stuffing box, while the piston was to be forced down, not by the air, but by steam introduced above it.

The cylinder was cooled, too, by the open air on its side; this Watt remedied by enclosing the cylinder in a second case covered with wood, and filling the space between with steam. Thus, all

[1] Muirhead, quoting Watt's own account of his invention, p. 79. Also *Mr. Watt's Specification of His Method of Lessening the Consumption of Steam and Fuel in Fire Engines*, Tangye MSS., printed for propaganda purposes.

[2] *Specification*, Tangye MSS.

Watt's improvements were economical of heat. Economy in heat meant economy in steam, and economy in steam meant economy in working costs, and, above all, in coal.

Watt now spent all his spare time in reducing the theory of his improvement to practice; he carefully thought out all the details, and calculated the amount of steam required. But, before long, he felt the need of an experiment on a large scale.

That is the story of the inventor, but the invention was a long way from being a commercial proposition, and much money had to be spent, and much capital laid out before Watt was in a position to supply "power to order."

Watt himself had no money to spend on experiments, and no capital with which to start manufacturing steam-engines, should his experiments prove successful. Therefore, he had to look elsewhere for his capital, and the two men who provided it, and made possible the successful development, were Roebuck and Boulton. Their story forms an important chapter in the history of capitalism, and in their careers can be seen most of the difficulties and opportunities that faced the men who became the leaders of the Industrial Revolution.

(2) *Roebuck*

Roebuck was born at Sheffield, in 1718. The son of a cutler, he was educated at Edinburgh and Leyden, and settled in Birmingham to practise as a physician. While there he met Samuel

Garbett, the first of the great Birmingham men who were to have such an influence on the economic developments of the century. In conjunction with Samuel Garbett, Roebuck established a large laboratory, in which he discovered more economical and improved processes for refining and working gold and silver, and made the important discovery of a commercial method of preparing sulphuric acid in leaden vessels, at a quarter the cost of the glass retort method that had previously been in use.

The two partners established a manufactory of sulphuric acid at Prestonpans, in East Lothian, in 1749; the consumption of the article increased rapidly, and the undertaking was exceedingly profitable. They, therefore, added to their manufacture, and established a pottery for making white and brown ware, which was also successful.[1]

After these various manufactories had been running for some time, Roebuck became fairly rich, and was considered sound financially; therefore, when he resolved to establish in Scotland a manufactory of iron on a large scale, he was able to obtain the necessary capital from his friends in England and Scotland. He had met in Prestonpans a certain Mr. Cadell, who had unsuccessfully attempted to start an iron-works and who was very eager to develop the backward industry of Scotland.[2] Roebuck formed a company, but this

[1] *Transactions of Royal Society of Edinburgh*, IV, p. 65, 1796. Muirhead, *op. cit.*, p. 162. Watt to Small, Jan. 28, 1769, Tew MSS.

[2] Smiles, *Industrial Biography*, p. 135. Muirhead, *op. cit.*, p. 163.

company merely provided the capital, and left the entire direction of the business, buildings, machinery, processes, and site all to him. After mature consideration, he decided on a spot, on the banks of the river Carron, in Stirlingshire, where there was much water-power, ready transport by sea, and, in the immediate neighbourhood, good supplies of iron ore, lime stone, and coal.

This is a decisive change in the structure of industry. In the generality of cases previous to this date, an industry had become localized in a particular district by natural selection. Industries had been established in many places by accident, nearness to the continent being, in many cases, the most obvious of determining factors. Then gradually they throve, and increased in some places more than others, until gradually they died out in the unsuitable neighbourhoods, and became localized in the places that were most suitable. This is especially true of the woollen industry. From being almost universally practised, it became localized first in three districts—the south-western, round Stroud; the eastern, round Norwich; and the northern, in the West Riding of Yorkshire; then later it was largely confined to the West Riding.

The contrast between this evolution of localization, and the considered planting of a works by Roebuck, shows that a new era is at hand; it is the conflict of the two forces that are at war during the last half of the eighteenth century—historical evolution and abstract right. The principle was at issue between Burke, who believed in the his-

torical evolution of the constitution, and the French Revolutionaries, who would have built their state on the abstract principles of right and justice expressed by Rousseau and the philosophers.

Roebuck went further than this: he imported his engineer and his workmen from England. The Carron Iron-works were Smeaton's first work in Scotland, though he had long been a friend of Roebuck.[1] The first furnace was blown at Carron, in 1760, and the works proved a lucrative investment.[2] Roebuck was indefatigable in improving the manufacture; from the beginning he employed pit-coal for smelting his iron, and to do this, he had need of Smeaton's advice, in order to increase his blowing apparatus. Moreover, in order to improve the transport to Glasgow, the Carron Company surveyed a line for the Forth and Clyde Canal, which, though at the time abandoned, owing to the objections of the landlords, was later carried into execution on the lines of the original suggestion.

The question of the coal supply now received the attention of Roebuck; he seems to have determined from the beginning to control all his raw materials. He, therefore, leased the coal-mines belonging to the Duke of Hamilton, at Borrowstoness, as well as the salt pans that were connected with them.

Roebuck discovered that in order to keep the pits clear of water, the most powerful pumping apparatus was necessary; Newcomen's engine was

[1] Smiles, *Smeaton and Rennie*, p. 147. See *Reports of the late John Smeaton, F.R.S.*, 3 Vols., 1812. Vol. I, pp. 359, 412.

[2] Muirhead, *op. cit.*, p. 164.

found to be insufficient,[1] and it was with satisfaction that Roebuck heard of Watt's invention from their mutual friend, Dr. Black. Watt had been pursuing his invention for years, and, always lacking capital, had by 1768 borrowed £1,200 from Dr. Black.

Soon after the invention of the separate condenser, Watt was in communication with Roebuck, and he kept him informed of the progress of his experiments.

Roebuck wished Watt to construct a large engine at Kinneil, and put his invention to a practical test, with the assistance of the skilled workmen he had brought from Carron. Watt, however, was busy making enough money to keep his family by surveying.[2] However, in 1768, the engine was working, and Watt paid his long promised visit to Kinneil, and an arrangement was made with Roebuck.

Roebuck, who was at this time at the height of his career and looked to Watt's engine to assure his coal-mine of permanent success, agreed to discharge his debts, obtain a patent, and pay for the expenses of the experiments, in exchange for a two-thirds share in the invention.[3]

Watt went to London, in 1768, about his patent,

[1] Watt made careful calculations of the performance of this engine. Watt to Roebuck, Oct. 2, 1765, quoted in Muirhead, *Mechanical Inventions of James Watt*, Vol. I, p. 7.

[2] 1760, Watt reported on the methods of improving the navigation of the Firth. 1767, he surveyed the Forth and Clyde Canal. Muirhead, *op. cit.*, p. 172.

[3] Boulton to Roebuck, July 9, 1768, Tew MSS.

which was obtained in the following year. On his way home he called on Boulton, at Soho, where the latter, ignorant possibly of the exact relations which existed between Watt and Roebuck, offered to take a share in the fire-engine.

Watt having consulted with the Doctor, who was beginning to feel the effects of his large commitments, offered Boulton a third share in the undertaking, if he would bear half the expenses.[1]

[1] Watt to Boulton, October 20, 1768, Tew MSS. : " I got safe home on Wednesday last week, when you were so kind as to express a desire to be concerned in my fire-engine. I was sorry I could not immediately make you an offer, the case is this : By several unsuccessful projects and expensive experiments I had involved myself in a considerable debt before I had brought this theory of the fire-engine to its present state. About three years ago a gentleman who was concerned with me dyed, as I had at that time conceived a very clear idea of my present improvements and had even made some tryal of them, though not so satisfactory as has been done since Dr. Roebuck agreed to take my debts upon him and to lay out whatever more money was necessary either for experiments or securing the invention for which cause I made over to him two-thirds of the property of the invention, the debt and expenses are now about £1,200. I have been since that time employed in constructing several working fire-engines on the common principles as well as trying experiments to verify the theory, etc. The Doctor from his engagements at Borrowstoness and other business cannot pay much attention to the executive part of this, the greatest part of it must devolve on me, who am from my natural inactivity, want of health, and resolution, incapable of it. It gave me great joy when you seemed to think so favourably of our scheme as to wish to engage in it and therefore made it my business as soon as I got home to wait on the Doctor and propose you as one I wished he would make an offer, to which he agreed to with a great deal of pleasure, and I will write you in a few days that if agreeable you may be a third part concern on paying half the cost and whatever you may think the risque he has run deserves, which last he leaves to yourself. If you should not chuse to

Unfortunately, Boulton was almost without money, he says, "Doctor R's proposal is perfectly agreeable to us, only as to me it is, unfortunately, made after the engagement of nearly all my money.[1] I cannot help adding a word of congratulation upon the great prosperity of your colliery."

The situation in 1769 was that Watt was engaged in constructing "an engine of an 18 in. cylinder and 5 ft. stroke at Kinneil," and Watt says that "Doctor Roebuck's colliery is in a very thriving condition, and daily improving," though "some people in Birmingham have an interest in doing all in their power to lessen his character and credit."[2] This must have been the beginning of the end: Watt's engine was not available for pumping the colliery, and Roebuck began to be in financial difficulties. However, some of the other undertakings went well, for even in 1771, Watt says, "our pottery does very well, tho' we make damned bad ware."[3] However flourishing the undertakings were in 1769, in that year an agreement was finally made by Roebuck with Boulton and his friend,

engage on these terms we will make you an offer when the whole is more perfect, which I hope it will soon be. . . .

. . . If the Doctor Small should chuse to be concerned with you in this, I have occasion to think it would be agreeable to Dr. Roebuck, and would be highly so to me. . . .

Watt to Boulton, Dec. 12, 1768, Tew MSS.

". . . I have almost finished a most compleat model of my reciprocating engine; when it is tried I shall advise the success. . . ."

[1] Boulton to Watt, October 10, 1769. Tew MSS.

[2] Watt to Small, April 28, 1769. Tew MSS.

[3] Watt to Small, December 24, 1771. Tew MSS.

Small, under which they were to take a third share, and, in exchange, to pay half the expenses.[1]

Roebuck's difficulties went on increasing, and lack of capital made him frightened of delays. It was unfortunate that this occurred just at a time when the banks were restricting their credit in consequence of bad harvests, and the unwise speculation that had been going on. 1763 had been a critical year for the credit of Europe. The Bank at Amsterdam had refused to support a firm, called Neufville, which had large connexions, and this disaster extended to England; fortunately, the Bank of England was able to support the credit of the principal houses, not only of England, but of Hamburg and Holland.[2] Moreover, from 1769, there was a rapid increase in our exports, and the inevitable reaction, which came in 1772, was accentuated by the failure of Neale, James, Fordyce, and Downe, a large London firm, whose failure also affected the Scottish banks.

The recently established Bank of Ayr had been founded to relieve the distress of the country. This bank was more liberal than any other in granting credit and in issuing notes,[3] while the Bank of Scotland worked hard to enforce the retirement of the notes of other banks. The Ayr bank was unable to keep pace with this movement, and, moreover, its London agents refused to help it any longer. Thus, the failure of Neale's merely hastened its

[1] Watt to Small, December 12, 1769. Tew MSS.
[2] Adam Smith, *Wealth of Nations*, Vol. I, p. 285.
[3] In a week the Bank advanced £1,600,000. *Ib.*, Vol. I, p. 278.

collapse along with other mercantile banking houses.[1] Almost every private banker in Scotland failed during this period.

This was an unfortunate time for Roebuck to be in difficulties. For a restriction of credit was the only method of restoring financial stability.

Adam Smith says that "the paper which was issued upon those circulating bills of exchange amount, upon many occasions, to the whole fund destined for carrying on some vast and extensive project of agriculture, commerce, or manufactures . . ." This was a capital which those projectors had very artfully contrived to draw from those banks, not only without their knowledge or deliberate consent, but for some time, perhaps, without their having the most distant suspicion that they had really advanced it."[2] "When a banker had even made this discovery, he might sometimes make it too late, and might find that he had already discounted the bills of those projectors to so great an extent that by refusing to discount any more, he would necessarily make them all bankrupts, and thus by ruining them, might perhaps ruin himself. The difficulties accordingly which the Bank of England, which the principal bankers in London, and which even the more prudent Scotch banks began after a certain time, and when all of them had already gone too far, to make about discounting, not only alarmed,

[1] Graham, *One Pound Note*, pp. 111–2. The Bank of England held £150,000 of their paper.

[2] Adam Smith, *op. cit.*, Vol. I, p. 277.

but enraged in the highest degree those projectors."

In many cases, the projectors expected the banks to go on supplying them with capital as long as their ventures failed to give them any return. The banks had been financing the maddest and most insane undertakings; but the panic of 1772, and the gradual experience and development of technique of the bankers, made them wiser, and "by refusing, in this manner, to give more credit to those to whom they had already given a great deal too much, took the only method by which it was now possible to save either their own credit or the public credit of the country."[1]

Thus, in 1772, Roebuck's already wavering fortunes were involved in the commercial crisis, and he became insolvent.[2] This placed Watt in a difficult position. Roebuck was neither financing him, nor paying for the experiments that had already been made, though Watt was self-reproachful that "the Doctor should be out so great a sum upon this affair, while he has otherwise such pressing occasion for money."[3]

About this time, in a letter to Small, Watt makes the curious statement that "as to the engine, I am not afraid of being able to carry it on with a small capital or almost none, provided the success was certain; or that I was in such circumstances as to be able to make the necessary experiments

[1] Adam Smith, *op. cit.*, Vol. I, p. 278.
[2] Muirhead, *op. cit.*, p. 196.
[3] Watt to Small, August 30, 1772. Tew MSS.

for establishing its merit."[1] Watt must have been thinking how it would be possible to retain control of his monopoly, and supervise and improve the engine at the same time. The result of these thoughts appears in some of the rather curious arangements made for production, when Watt and Boulton finally began to produce engines.

Roebuck's affairs showed no signs of improvement, and as he was anxious to see the steam-engine carried to completion, he was quite willing for Boulton and Small to purchase the whole of his share in the patent. In July, 1773, Watt was afraid that Roebuck would not pay 10s. in the pound, and as "none of his creditors value the engine at a farthing,"[2] there seemed nothing in way of a transference. This was soon done, but as Small had engaged all his funds, it was to Boulton alone, and he obtained Roebuck's two-thirds share of the engine patent in exchange for a remission of a debt of £630, and a payment of £1,000 out of the first profits of the partnership of Boulton and Watt.[3]

A curious point arises in regard to Boulton's debt, and the question of unlimited liability. In a letter to Boulton, Watt says, "Besides the one part of your debt you have no legal claim for, perhaps they might, if it was mentioned, construe that money as advanced with a view to profit as a partner, whereby you might be subjected to greater loss than that of the capital."[4]

[1] Watt to Small, November 7, 1772. Tew MSS.
[2] Watt to Small, July 25, 1773. Tew MSS.
[3] Watt to Boulton, July, 1773. Tew MSS.
[4] Watt to Boulton, July, 1773. Tew MSS.

In exchange for the remission of the £630, the creditors were to empower the Doctor to make over all his property in the engine to Boulton, "for all the models, etc.," were Watt's, and on May 20, 1773, Watt writes to say he has sent off the engine to London by boat on its way to Birmingham.[1] It had been lying at Kinneil, open to the weather, but was to have a better fate when it reached Soho. Watt, however, was unable to go to Birmingham for some time. During the intervening years, from 1769, he was occupied in various engineering and surveying works, though by attracting capital to other undertakings, he was indirectly damaging his own chances of success with Roebuck. Among his works was a survey for the Caledonian Canal, which was afterwards successfully constructed by Telford.[2]

While he was engaged in this survey, he was recalled by news of his wife's illness, and he returned home, only to find her dead. The ties that bound Watt to Scotland were gradually disappearing. On May 17, 1773, Watt had effected his discharge from partnership with Dr. Roebuck, and early in 1774, Watt writes, "I begin to see daylight through the affairs that have detained me so long, and I think of setting out for you in a fortnight."

The contrast between England and Scotland at this date is interesting; both capital and labour were unequal, in the case of the northern country, to the task of producing the steam-engine, and

[1] Watt to Small, Kinneil, May 20, 1773. Tew MSS.
[2] Watt to Small, June 2, 1773. Tew MSS.

making it a commercial success,[1] and the inventor emigrated to England.

Roebuck lived on in obscurity till 1794, and though occasionally envious of the success of Boulton, deserves credit for his share in helping to lay the foundations of that success.

[1] Watt to Small, Glasgow, April 29, 1774. Tew MSS. In this letter Watt says " there are too many beggars in this country, which I am afraid is going to the Devil altogether ; provisions continue excessively dear and laws are made to keep them so, but luckily the spirit of emigrating rises high and the people seem disposed to shew to their oppressive masters that they can live without them. By the time some 20 or 30 thousand more leave this country, matters will take a turn not much to the profit of the landowners."

CHAPTER V

Watt's Partnership with Boulton

(1) *Boulton : The Hardware Manufacturer*

Boulton had had complete charge of the hardware business for some years before his father's death, which occurred in 1759. He inherited a considerable fortune, which had been accumulated in the business, and the next year he married Anne Robinson, a wealthy heiress, in spite of considerable opposition from the lady's friends on account of his occupation.

Boulton was now in an established financial position, and might easily have retired from the trade, but instead he entered into it more vigorously. He was determined to establish a business that should be the foremost of its kind. The firm's earliest premises, on Snow Hill, having become too small, Boulton decided to remove to Soho, about two miles north of Birmingham, on the Wolverhampton road, where he built himself more commodious premises. Before taking this step, he took into partnership a Mr. John Fothergill, who had a limited capital, but was a very active business man. The removal was important for many reasons.

In the first place, Boulton had to use both his

wife's fortune and his own for the venture, £20,000 being sunk in buildings and equipment. In consequence of this development, new connexions and agencies were established at home and abroad, and Boulton took the greatest care in selecting artistic designs for his productions, and extending the range of his manufactures. The business rapidly developed; the gross receipts of the firm increased from £7,000 in 1763, to £30,000 in 1767,[1] and the fame of the manufactory had spread all over Europe. Even in France, the home of fashion itself, Boulton & Fothergill had correspondents at Marseilles, Lyons, Aix, Montpellier, Paris, and Rouen,[2] while so important was the Russian trade, that Fothergill spent a whole year travelling in Russia and Sweden.

The natural result of this large increase of business, immediately after so much capital had been sunk in permanent improvements, was embarrassing to the firm. In a letter to his friend, Baumgarten, Boulton says, "The number of our friends and customers are every day increasing, and so are our orders, consequently the money required must also be increased, for nothing will have a tendency to extend our dealings so much as giving a little indulgence in point of credit to such friends as are solid and safe. And, therefore (as I very well knew our circulating capital would be too little for our undertakings), I intended, in the course of this summer, to add to our capital two or three

[1] Smiles, *Boulton and Watt*, p. 177.
[2] Boulton to Wicke, August 22, 1767. Tew MSS.

thousand pounds." He asks Baumgarten for a loan, but if it becomes necessary, announces his intention of mortgaging one of his private estates, to prevent the business languishing.[1] This was in 1767, and Boulton was now an enterprising and energetic manufacturer, understanding to the full the difficulties of expanding a small business into a large capitalist undertaking, and quite unafraid of the bogey of overtrading. Nevertheless, Boulton realized that he was a pioneer, that there was a difference of degree, as well as of kind, between his father's modest works on Snow Hill and the elegantly built manufactory at Soho,[2] and that there was an increasingly wide gulf between employer and employed.

The apprentice who married his master's daughter was rapidly becoming a legend. Boulton, in reply to an application that he should take the brother of one of his friends as an apprentice, said, " I do not think it an eligible plan for your brother, as it is not a scheme of business that will admit of a mediocrity of fortune to be employed in it. It even requires more than is sufficient for a considerable merchant, so that a person bred in it must either be a working journeyman in it, or he must be possessed of a very large fortune."[3] This is the

[1] Boulton to Bargum (Baumgarten), August 5, 1767. Tew MSS.

[2] Arago, *James Watt*, 1854, p. 420 : " Une manufacture de M. Boulton existait déjà depuis quelques années à Soho, lorsque naquit l'association qui a rendu son nom inséparable de celui de Watt. Cet établissement, le premier sur une aussi grande échelle qui ait formé en Angleterre, est encore cité aujourd'hui pour l'élègance de son architecture."

[3] Boulton to Peter Bottom, March 30, 1768. Tew MSS.

position in many trades by 1750, the gap between the economic classes has widened. The masters who devote all their energies to production have become fewer in number, the amount of capital necessary to set up has increased, and the only prospect before the generality of apprentices was the wage-earning status of a journeyman.

Moreover, business organization was becoming more scientific, and this is an important development. When all labour depends upon acquired personal skill, and business success upon the energy and capacity of the individual, it is possible for sharp vicissitudes to occur in the history of firms. But a firm like that of Boulton was uniformly successful from 1740 to 1850, and this was due, first to its machinery, which, by replacing individual skill, made all advances in technical skill permanent ; and, second, to its business system and organization, which continued the business acumen and vigour of Boulton when his guiding hand was removed.

In 1770, Boulton arranged for a meeting of the partners and managers of Soho to take place once a week to examine the state of the business during the past week, the state of the orders in hand, price-lists, " any other regulations, alterations, resolutions, necessary to be made, or any new mode of proceeding adopted," and " that no important points relative to our foreign trade be determined but at such meetings, as well as important letters to be written or to be answered."[1]

[1] *Memorandum* in Boulton's writing dated November 27, 1770. Tew MSS.

Watt, himself, paid his first visit to Soho in 1767, and "the goods then manufactured there were steel, gilt, and fancy buttons, steel watch chains and sword hilts, Plated wares, Ornamental works in Or Moulu, Tortoise shell, snuff boxes, bath metal buttons, inlaid with steel, and various other articles, which I have now forgot. A mill with a bearer wheel was employed in laminating metal for the buttons, plated goods, etc., and to turn laps for grinding and polishing steel works, and I was informed that Mr. Boulton was the first Inventor of the inlaid buttons, and the first who had applied a mill to turn the laps. Mr. B., at that time, also carried on a very considerable trade in the manufacture of buckle chapes, in the making of which he had made several very ingenious improvements. Besides the laps in the mill, I I saw an ingenious lap, turned by a hand wheel, for cutting and polishing the steel studs for ornamenting buttons, chains, sword hilts, etc., and a shaking box put in motion by the mill, for scowering button blankes and other small pieces of metal, which was also a thought of Mr. Boulton. There was also a steel house for converting iron into steel, which was frequently employed to convert the cuttings and scraps of the chapes and other small iron wares into steel, which was afterwards melted and made into cast steel for various uses."[1]

[1] Glasgow, September 17, 1809, *Memorandum Concerning Mr. Boulton, Commencing with My First Acquaintance with him, by James Watt.* Tew MSS.

It is evident that Boulton was fully aware of the value of the division of labour, and that his works, even with the limited power at his disposal, were beginning to be largely machine operated. In the organization of his business, Boulton consciously practised a thorough division of labour, and realizing all the benefits of Adam Smith's celebrated pin-maker, taught all his workpeople some special department, and made every one a skilled hand. In 1770, he employed 800 persons, and though the financial panic of 1771–2 shook him severely, he continued his plans and expansion.[1]

Boulton was a business organizer, and possessed "marketing ability of a constructive order."[2]

The removal to Soho, and the consequent increase in capital, had made necessary this development of business organization, while the mere increase in the size of his works had made more power necessary to drive them.[3] Capital and power were necessary, and they became the two necessities of all modern industry; and the order in which industries have fallen into modern industrial methods, depends largely on the ease with which steam-power was applied to them. Among the characteristics which affect the introduction of steam-power to industry are the size and structure

[1] Timmins, *Matthew Boulton* in *Trans. Birmingham Arch. Soc.*, Vol. II, p. 26.

[2] Marshall, *Industry and Trade*, p. 47.

[3] "Water power—about 6 to 8 horse power and costing five to eight guineas a week—had hitherto been the mechanical motor at Soho." S. Timmins. *Birmingham Arch. Society Transactions*, Vol. II, p. 27. *M. Boulton.*

of the industry, the fixity and uniformity of the demand for its products and the durability or valuable properties of its products[1] All these characteristics were present in the hardware trade, just as they were in the iron and pottery industries and in the mines, though in some of these, machinery was opposed to the skilled labour element, which even yet persists in some of the pottery and glass trades.

In Boulton, the hardware trade and capitalist industry, as a whole, had a wealthy and intelligent leader, and it was his efforts that brought steam power into the market as a commercial proposition. Boulton was the right man at the right moment for England's foreign trade ; long freedom from invasion had given her the power of capital even before she needed it, and there was scope in the middle of the eighteenth century for men with this marketing ability of a constructive order. The removal to Soho had called for a large increase in capital, and had thus marked a long step forward in the history of the firm, but it had another, and more universally important consequence. The power at Soho was derived from the Hockley Brook, which flowed round the hill on which the works stood and was collected in a pool.[2] Unfortunately, this source of supply, feeble at the best of times, was very easily affected by dry weather, and was

[1] Hobson, *Evolution of Modern Capitalism*, p. 90–1.

[2] Smiles, *Boulton and Watt*, p. 168: "Hooper was here this morning to talk about an engine. Hockly Pool is green grass, and all the mills below panting. When the Devil was sick the Devil a saint would be." Boulton to Watt, Aug. 16, 1781. Tew MSS.

a constant source of anxiety to Boulton. He was well informed on the subject of scientific experiments, and decided to adopt a steam-engine for the purpose of pumping water into the pool, and, early in 1766, he wrote to Benjamin Franklin on this subject:

"My engagements since Xmas have not permitted me to make any further progress with my Fire-Engine, but as the thirsty season is now approaching apace, necessity will oblige me to set about it in good ernest. Query—Which of the Steam-Engines do you like best? Query—Is it better to introduce a jet of cold water in at the bottom of the receiver (which is about three feet from the top) or in at the top? Each has its advantages and disadvantages. My thoughts about the secondary or mechanical contrivances of it are too numerous to trouble you with."[1]

The steam-engine, which had been carried through its experimental stages by Savery and Papin, in the first years of the century, had been made a practical machine by Thomas Newcomen, assisted by John Calley. It had been improved at various times, but it was still an uncertain and expensive worker. The improvements were due, first, to Newcomen himself, later to the different people responsible for the engines, and also, in a very large degree, to chance. The leading engineers of the country, Brindley and Smeaton, were also deeply interested in the steam-engine, and it is probably to one of Smeaton's variations and the

[1] Boulton to B. Franklin, February 22, 1766. Tew MSS.

original machine that Boulton refers in his letter, and between which he is hesitating.[1]

As a matter of fact, he adopted neither.

It was at this time that Boulton was introduced to James Watt, and at the failure of Roebuck, Boulton bought his share in the steam-engine patent; and in 1774, Watt came to Birmingham, and the engine, which he had designed for the Kinneil coal-mines, was erected at Boulton's works, at Soho, to pump water to drive the works.[2]

Thus, began the partnership that was to be one of the most important economic events of the century.

(2) *The Significance of the Partnership*

The partnership, that began in 1775, had most far-reaching effects. It was, in fact, the union of one of the most inventive brains of the age with one of the first great commercial intelligences, for the purpose of selling the most valuable thing in existence—"power."

Moreover, it was a form of power that was applied most readily to the production of coal which, after the first half of the eighteenth century, had replaced agriculture as the main prime source of capital.[3] This translation from agriculture to industry, meant a change from a country with

[1] Smiles, *Boulton and Watt*, pp. 63–5.

[2] Boulton to John Lockwood, August 14, 1775. Tangye MSS.: "I have returned the water to my mill all this summer by means of one of them" [Watt's steam-engines].

[3] See Jevons, *Coal Question*, *passim*.

limited powers of development, to one with enormous scope for expansion. The getting of coal meant the getting of power and the getting of wealth ; while the steam-engine, which was invented to meet the demand for pumping power,[1] was the chief instrument in the rapid increase in capital that took place. The fact that Britain was the country in which the steam-engine was invented, and, consequently, was the first great coal nation to put her coal to economic use, was the secret of her rapid comparative advance.[2]

But the invention of the steam-engine had more than this general and direct effect on the accumulation of capital. For the industries that needed "power to order" it had a peculiar significance. For them it meant the development of a machine economy, and an increase, variously great, in the amount of their fixed capital. Moreover, its effect on the labour power employed was two-sided ; in the long run, it largely increased the number of labourers required and reduced the importance of technical skill, but in individual industries it completed the breach between employer and employed—they were separated completely. A capitalist class had been evolved, and admission to its ranks could only be obtained by accident. The progress of apprentice to master was the exception instead of the rule, and the line of

[1] This is established by the story of all mining operations, but is especially true of the tin-mines and the coal-mines, which had been worked at the earliest date.

[2] Sir Geo. G. Chiozza Money, *The Future of Work*, p. 95.

cleavage that has troubled the world ever since had been drawn.

(3) *History of the Partnership*

Watt left Glasgow to come to England in May, 1774,[1] whither the engine had already preceded him. Boulton having erected the engine in November, 1774, the trials were full of promise, and Watt wrote to Roebuck that "the fire-engine I have invented is now going, and answers much better than any other that has yet been made."

Boulton, however, hesitated to launch out into the large expenses that an adequate establishment for the manufacture of engines would entail, unless he was assured of a monopoly for longer than the eight years yet remaining.[2] Already, in 1769, pirates were in the field; Watt laments "that in life there is nothing more foolish than inventing, here I work five or more years contriving an engine, and Mr. Moore hears of it, is *more eveillé*, gets three patents at once, publishes himself in the newspapers, hires 2,000 men, sets them to work for the whole world in St. George's Fields, gets a fortune at once, and prosecutes me for using my own invention."[3]

Though this letter of Watt is ironical, he had already had difficulties with imitations, one of his workmen, at Carron, had stolen and sold the plans

[1] Watt to Small, Glasgow, May 6, 1774. Tew MSS.

[2] Watt's original patent, granted in 1769, was for fourteen years. It was possible that some of the remaining eight would be consumed in experiments.

[3] Watt to Small, July 26, 1769. Tew MSS.

of the Kinneil engine; and as there was likely to be a great demand for an engine, so economical in coals, Boulton naturally desired security in their possession.

Thus, in January, 1775, after the engine had proved satisfactory, Watt went to London to arrange for an extension of the patent. The whole question was raised in Parliament. This Act of Extension, though backed by the powerful influence of Boulton, and with "the assistance of Dr. Roebuck and all the friends"[1] they could muster, was only obtained with great difficulty. It was made the occasion for re-opening the whole question of monopolies, that had been fought over and over again in the House of Commons during the preceding two hundred years.

Under Elizabeth, Burleigh had made deliberate efforts to foster home industries by granting patents for new enterprises. The results of this were highly important. The study of the patents of Elizabeth's reign have brought into prominence the fact that the inception of processes and industries was a capitalist undertaking, financed by moneyed men, who were ready to wait some time for a return on their capital.[2]

As long as the patent was given to a man who

[1] *Memorandum of Matthew Boulton*, by James Watt. Tew MSS.

[2] Cunningham, *Growth of Industry and Commerce*, Vol. II, p. 78. Scott surmises that the original attacks on monopolies were due to a commercial depression in 1586, and the resentment shown by the commercial community towards the growth of a non-commercial community. Scott, *op. cit.*, Vol. I, p. 110.

introduced a new process or introduced a new branch of industry, the system was beyond reproach, but the patents became oppressive when the internal trade in certain articles was given over to a grantee. Under the Stuarts, who were faced with the difficulty of governing the country on an insufficient revenue, though patents which trenched on the liberty of internal dealing were viewed with suspicion, they promised too convenient a means of obtaining money for them to be abandoned, and grants of monopoly were used in an unscrupulous manner, to obtain funds for the royal exchequer.

Nevertheless, though some hardship and jealousy resulted, the increase in the number of England's industries in the seventeenth century, due to this system, was very rapid. The system, in the case of genuine inventions, first of all, had the support of public opinion, for in Elizabeth's reign respect for private interests was very strong. This state was succeeded by violent attacks on the system when it was improperly used, for it is noteworthy that at the time when monopolies were granted most freely invention was the rarest.[1]

The Mercantilist philosophy, of course, supported patent rights and monopolies, and though, in 1775, Burke raised his voice for freedom, and against the patent, Watt's Bill was passed by both Houses, and his monopoly extended to 1800.[2] This was at the beginning of the movement for freedom of

[1] Marshall, *Industry and Trade*, p. 228.
[2] The Bill was from February 22nd till May 8th in passing.

trade and toleration, and ten years later, Boulton and Watt found themselves on the same side as Burke, advocating free trade with Ireland.[1]

It is supposed that Burke was influenced by the mining interest in the neighbourhood of Bristol, which city he then represented.[2] This seems very doubtful in view of his well-known views on the subject of the control of the representative by the electorate, and the fact that for his views on trade and toleration the City of Bristol discarded him in 1780. But Burke's opposition was more probably due to his natural hatred of monopolies, and to the fact that Boulton and Watt had applied for their Act on the advice of Wedderburn, with whom Burke at this time was struggling over the American question in the Commons.[3]

It would, indeed, have been curious if the first stirrings of economic liberalism had made it impossible for Watt to improve and make useful the greatest agent for expansion that has ever been invented. There is no doubt that it would have been better for the community at large had Watt perfected his engine and given it to the world to use free of charge, but it would have been impossible for Watt to invent and experiment on it for years had he not been able to draw on capital, from which the owners were, by all the standards of the eighteenth century, entitled to a return.

[1] *An Answer to the Treasury Paper on the Iron Trade of England and Ireland*, by James Watt. Tangye MSS.

[2] Smiles, *Boulton and Watt*, p. 157.

[3] M'Cormick, *Life of Burke*, 1798, p. 159.

All the inventors of the eighteenth century had difficulty over their patents. Both Arkwright[1] and Watt had to spend much time in courts of law to defend their positions ; while the resentment felt by contemporaries for people who controlled something so intangible and so desirable as an exclusive right to make a necessary machine, probably prevented Crompton from obtaining for his "mule" the patent, which was afterwards secured by Arkwright. In evidence, before a Commons Committee, dealing with Samuel Crompton's claims in 1812, it was said that the method of reward to an inventor, as generally accepted in the eighteenth century, was that the machine, etc., should be made public, and that a subscription should be raised by those interested, as a reward[2] to the inventor. This was all right before invention required much capital, but by 1750, capital was absolutely essential for the production of any great technical improvement, and every successive expansion of industry increased the advantage of a capitalist-inventor over the penniless one.[3]

Watt, having obtained his patent, and his invention being recent, he was, for a time, safe from molestation. Boulton concluded the arrangements with Roebuck, and definitely entered into

[1] Daniels, *Early English Cotton Industry*, pp. 100–102, 118, 186–7.

[2] *Ib.*, quoting *J. H. C.* LXV., II., 838-839.

[3] Marshall, *Industry and Trade*, p. 244 : "Experiments on the laboratory scale or with small mechanical models have as a rule but little commercial value until they have been fortified by practical proof of their efficiency on a working scale."

partnership with Watt.[1] Fothergill, his other partner, refused to be included,[2] and Dr. Small died while Watt was obtaining the patent. Thus, the steam-engine firm was founded under the title of Boulton & Watt.[3]

The history of the firm is interesting along two lines. In the first place, the capitalization of a large industrial firm, whose products were costly, was a difficult business, as the failure of Roebuck at the outset of the enterprise shows; and, secondly, the story of the capitalization of industry generally is illustrated by the firms and industries to which Boulton & Watt supplied their engines.

(4) *Early Development and Capitalization of the Firm.*

Boulton had already spent £2,200 on his share in the partnership, and though Watt had just married for the second time, and his wife was a lady of some fortune,[4] Boulton was to finance all experiments and patents without any assistance from Watt, who relied almost entirely on Boulton for support until the engine began to pay. It is curious that the steam-engine should have been made

[1] Smiles, *Boulton and Watt*, p. 159. Boulton had paid off the £1,200 debt and the £1,000 out of the first profit to be rid of the importunity of Roebuck's creditors. Boulton to Watt, June, 1775. Tangye MSS.

[2] Roebuck owed the money to both Fothergill and Boulton. Boulton to Watt, March 29, 1773. Tangye MSS.

[3] Watt to Enslie (of Rotterdam), July 14, 1775. Tangye MSS.

[4] Muirhead, *Life of Watt*, p. 257. Watt to Boulton, from Glasgow, July 28, 1776. Tew MSS.

possible by the industries that it was destined to serve ; Roebuck financed Watt out of the proceeds of coal-mines and potteries, Boulton out of hardware.

While Watt was in London on patent business, he examined the engine used for pumping water at New River, Hungerford, and Chelsea. They were atmospheric engines of the Newcomen types, as improved by Smeaton, but Watt was unable to obtain any accurate figures of the performances.[1]

The patent obtained, and the model at Soho working well, Boulton & Watt were ready to execute orders. Already in 1771, on Boulton first entering into negotiations with Roebuck, Small wrote to Watt " that four or five copper mines are just going to be abandoned, because of the high price of coals," " the York Buildings Company delay rebuilding their engine . . . waiting for yours . . . and a mining Company in Derbyshire . . . must quit their mine if you cannot relieve them."[2] Boulton was well known in the country, and had commercial connexions with many industries, and his partnership in the engine business was a ready advertisement for it.

The engine brought from Kinneil had been fitted with a new cylinder, cast and bored by John Wilkinson. The first cylinder had been bored by an apparatus installed by Smeaton, at the Carron

[1] Smiles, *Boulton and Watt*, p. 134.

[2] Small to Watt, February 14, 1771. Quoted Muirhead, *Mechanical Inventions of James Watt*, Vol. II., p. 15.

Works, but Wilkinson had invented a machine which bored much more accurately.[1]

During 1775 they received many inquiries for various types of engines, and Watt continued with his experiments, both on the reciprocating pumping engine, and on a steam-wheel working with weights. This last caused him much wasted time, and for the present he devised no practical machine.

In starting a new firm, the difficulties which confronted them were, as ever, those of providing capital and intelligent labour. The demand already existed, the supply had to be arranged.[2]

For the first five or six years, the firm devoted the greater part of its attention to Cornwall, which seemed to be the most profitable source of income; then, in 1782, Watt patented a rotary motion, which enabled the engine to be applied to driving machinery and all the manifold purposes of power-using industry. Thereafter, the success of the firm was assured, though capital and labour were still difficult to obtain. From beginning to end

[1] Smiles, *Boulton and Watt*, p. 159. Boulton to S. Garbett, February 18, 1776. Tangye MSS. Garbett probably represented Roebuck's creditors. "Bore your cylinders as fine as Wilkinson's, and then say there is no truth in me if we are not good customers to Carron."

[2] "We have also made two different rotative or wheel-engines that are turned by the force of steam exerted within them . . . but although these engines have performed in such a manner as to satisfy us of the efficacy of the contrivance, yet there are some little deficiencys in the execution which we wish to cure before we offer them to the public." Watt to Proctor and Beilby, Sheffield, November 8, 1776. Tangye MSS.

they encountered the opposition of all who objected to monopolies, and had to contend with imitators and pirates during the greater part of their patent period. Moreover, in the course of the development of the business, the firm found themselves obliged to take shares in some of the enterprises to which they supplied engines, while various purchases of raw material brought them into connexion with the sources of supply.

Again, this was an age of increasing economic power. The commercial and industrial leaders took part in politics, and were a power in the land; both Boulton and Watt took a share in the various movements to oppose or support the economic foreign policy of the Government. Further, the firm organized its employees, and promoted beneficent and humanitarian institutions for them.

Along all these lines, the history of the firm of Boulton & Watt, and that of its close allies, John Wilkinson and Josiah Wedgwood, is the history of an economic progress, and the lines of development are best studied one by one.

CHAPTER VI

Capitalization of the Firm of Boulton & Watt

The first engine was ready to work in 1776, and was for John Wilkinson's iron works, at Broseley; one for Bloomfield Colliery, in Staffordshire, was ready almost[1] at the same time, while the first engine in London, was that for Cooke & Company's Distillery, at Stratford-le-Bow.

The arrangements and terms were from the beginning definitely fixed, and the effect of lack of capital upon the system of payment adopted, from the first, was clearly in evidence.[2] The cost

[1] Watt's *Memorandum on Boulton*. Tew MSS. Boulton to S. Garbett, February 16, 1776. Tangye MSS.

[2] Smiles is scarcely accurate in his account of the origin of the system of payment. He says that at first Boulton and Watt "were mainly concerned to get orders and were not very particular as to the terms on which they were obtained. But when the orders increased and the merits of the invention gradually became recognized they found it necessary to require preliminary agreements to be entered into as to the terms on which the engine was to be used." This seems to be inaccurate, for in a letter to Richard Lodge, of Gray's Inn, in answer to a very early inquiry for an engine, Watt writes, "in relation to my own profits, I do not propose to charge any upon the prime cost of the engine but upon the savings of fuel over any other fire-engine you please to compare it with," and the whole of the system is outlined in its finished state. Watt to Lodge, June 12, 1775. Tangye MSS. Moreover, there is a vague reference to the system as early as 1769. Watt to Small, May 28, 1769. Tew MSS.

of the erection of the Bloomfield engine was £2,000; the colliery paid for the materials of which the engine was composed, and for the labour necessary to erect it at the ordinary market price. Many of the bills were paid straight to Wilkinson, for the castings and foundry work that he supplied. On the parts that were supplied from Soho, Boulton & Watt got no profit, but looked to an annual payment to reimburse them for their capital expenditure on tools and workshops. This annual payment was based on the comparison of the consumption of coals by a common atmospheric engine, with those consumed by one of the new Watt engines. The amount of the saving, by using one of Watt's engines, was then to be divided between the owners of the engine and the firm of Boulton & Watt, in the proportion of two to one.[1] This curious system of payment was almost certainly devised by Watt.[2] It was ingenious and honest, but very difficult of application, as it laid the steam-engine company open to the attacks of all who felt inclined to defraud them. The amount of coals consumed, and the work the engine performed, were both difficult to estimate and supervise. Moreover, the fact that the engine owners had to continue paying Boulton & Watt rent for an engine, for

[1] Watt to Richard Lodge, Gray's Inn, June 12, 1775. Tangye MSS. Watt to Peter Capper, October 10, 1782.

Boulton & Watt's engine raised 83½ thousand cubic feet of water 1 fathom high per bushel of coal.

A good common „ „ 22 thousand cubic feet of water 1 fathom high per bushel of coal.

[2] All the earliest letters in which the system is described are Watt's composition.

which they had already paid, was a constant source of friction.

The real cause of the curious system of payment was, undoubtedly, lack of capital. The firm had not the money to spare to lay down large works and purchase large stores of raw materials, nor for that matter, had they the labour with which to build the engines.[1] Consequently, though this method of erecting engines did not mean prodigious expenditure of capital, yet it meant that the returns to the initial cost were correspondingly slow in coming in.

The charges against the business were, first, the peculiar tools necessary for the engineering business; among these was a new forge at Soho, and in 1781, a new engine-shop was erected. There were also travelling expenses of partners and workmen, expenses of the patents, and until the business began to pay, Watt was credited with £330 per annum. All this capital had to be found by Boulton, and though Fothergill, Boulton's partner in the hardware business, had refused to take any share in the engine business, much money, in the early stages, was borrowed from the older firm.

It was essential, if the engine business was to go on, that more capital must be procured, and the methods by which it was obtained are of the greatest possible interest and importance. The resources of Boulton & Fothergill were the foundation

[1] John Wilkinson did the major part of the iron work for the engines, thus relieving the engineering firm of the necessity for laying down immense sums in capital for iron founding.

upon which the rest of the structure was based. In 1780, a statement of the position of that firm was drawn up by the cashier, and he estimates that during the eighteen years, from 1762 to 1780, on the capital of £20,000, the firm had lost £11,000 ;[1] especially the painting and japanning side of the business, which was losing at the rate of £500 per annum ; however, Boulton himself was a man of substance, and his own credit was good. His wife had brought him £28,000,[2] but of this he had been forced to sell the Patkington Estate to Lord Donegal for £15,000,[3] and had, further, sold or mortgaged much of his father's property. This, however, was not enough.

Already, in 1778, before the engineering business had time to have much influence on their finances, Boulton & Fothergill were finding money difficult, and Fothergill was endeavouring to persuade their creditors to " differ their demands for a few weeks, and those who had it in their power do, in general, behave very tenderly."[4] At the same time, the engine company, which was just beginning its business in Cornwall,[5] was getting ever more difficult to work owing to the lack of funds. Up to this date, Boulton, who had, according to their partnership deed, advanced all stock in trade,[6] had pro-

[1] *Statement by Zach Walker.* Tew MSS.
[2] Boulton to Matthews, June 26, 1781. Tew MSS.
[3] Smiles, *Boulton and Watt*, p. 205.
[4] Fothergill to Boulton, February 7, 1778. Tew MSS.
[5] Watt's *Memorandum of Boulton.* Tew MSS. Chacewater started in September, 1777.
[6] Watt to Boulton re Partnership. Tew MSS.

vided his capital privately, either from his own estates or his share in Boulton & Fothergill. Latterly, however, he had had recourse to loans from his friends, Day, Wedgwood, and Wilkinson, but these loans were personal affairs, and the lenders had no share in the business, but were paid a fixed rate of interest.[1]

The situation of Boulton in 1778 was, in many ways, comparable to that of Roebuck in 1771, but the divergences in the position were all to Boulton's advantage. In the first place, his financial position was better established than Roebuck's, while he had the advantage of a better developed and more intelligent banking system, and no period of extreme financial stress at the time of his application for credit.

Boulton was at this time banking with the bank of Lowe, Vere, Williams & Jennings,[2] and a loan might have been possible from them, but, unfortunately, they too were passing through a period of difficulty. Boulton had bills refused by the Bank of England (although they had been accepted by Lowe, Vere & Co.), because the Bank was suspicious of their soundness. Nor was this peculiar, for at the beginning of the month of July, 1778, Boulton writes that "Jennings, the

[1] Day was the author of *Sandford and Merton*. He lent Boulton £3,000 at 4 per cent in July, 1776.

[2] F. G. Hilton Price, *A Hand-book of London Bankers* (1890), p. 177. "Williams Deacons Bank:—I have been unable to trace this banking house further back than the year 1771 when they appear in the London Directory under the style of Raymond Williams, Vere, Lowe, and Fletcher."

junior partner of L. V. W. & J. House, was absconded, and that he had accepted bills unknown to the House, and unentered in any of their books, to the amount of £180,000 for an Irishman, and as the bills now became payable, and nothing to answer them, Mr. Jennings took five hundred pounds and went off to France. This circumstance became instantly known to the publick, and was mentioned in the newspapers. A run and immediate ruin was expected to fall upon the House, but it took a more favourable turn in the minds of the people, and *no* run was made upon the House, and what was still (more) favourable was the transactions for the greatest part of the sum were done by Jennings between Christmas and Lady-day, whilst Sir Chas. Raymond was in partnership, and, therefore, he comes in for his share . . ."[1] However, the next day saw things in a less favourable light, Boulton, fearing that "L. & V. House—would be destroyed as a Banking house, and, therefore, I must find a new connexion . . . ."[2] The greater part of the business of this firm was, as yet, mainly commercial, and it was with the money gained from the West Indian trade that capital was eventually found to finance Watt. "Even in this emergency, Lowe, Vere & Company may yet be saved, if ye West Indian Fleet arrives safe from ye French Fleet . . . as many of their securities depend on it."[3]

[1] Boulton to Watt, July 2, 1778. Tangye MSS.
[2] Boulton to Watt, July 3, 1778. Tangye MSS.
[3] Boulton to Watt, July 3, 1778. Tangye MSS.

The bank had already advanced Boulton large sums, and in this time of extremity began to press for repayment, but the steam-engine firm wanted more advances not repayments. Boulton urged Watt to press for payments for the engines already erected in Cornwall,[1] and asks whether any advances were possible from Cornish bankers.[2] Watt, who was no business man, was unable to do either of these things, and wrote back to Boulton in a very hopeless strain. Nevertheless, in July, 1778, things were beginning to be serious. Watt, on Boulton's suggestion, had tried to persuade a Cornish bank to advance them some money, but the banks were very cautious, "and such is the nature of the people—and so little faith have they in our engine scheme, that very few of them believe it to be materially better, and, as far as I can judge, none I have conversed with would advance us £500 on a mortgage of it."[3]

Moreover, at the end of 1778, credit again became restricted, and great prices were given for ready money, and premiums were illegally offered for loans.[4]

[1] Boulton to Watt, July 2, 1778. "It is better to be pressing for the payment of our just debts than to be pressing and importuning Cold Friends to lend their money." Tangye MSS.

[2] Boulton to Watt, July 3, 1778: "If we could be assisted by any means with £5,000 we could be easy, and therefore I wish to exhort you to read, mark, learn if it were possible to raise as much in Cornwall." Tangye MSS.

[3] Watt to Boulton, Redruth, July 8, 1778. Tew MSS. The principal Cornish Bank was Elliott & Praed, which had as its London representative, Biddulph & Co.

[4] "It has been owing to the scarcity of money, says a correspondent, that people have lately very commonly given not

Matters improved slightly as the month (July, 1788) went on; by the eleventh Boulton had received a thousand pounds on account from Moscow from his hardware business, a thousand pounds as part payment for an order for plate, and another thousand pounds from his shares in the Birmingham Navigation Company. In spite of this, Lowe, Vere & Co. pressed for repayment, but Boulton persuaded them to delay, and obtained their promise in writing.[1] During this month, too, a fire broke out in the engine-house at Soho, and damage estimated at from three to four thousand pounds was done, part of which was covered by insurance.[2] However, matters became more difficult, and although, in August, Watt sent a draft to pay Wilkinson's account for erecting Ting Tang engine, which they had already met,[3] it was very long before the first annual payment for the engine was made.

Things seemed hopeless. Watt, in this extremity, suggested the introduction of John Wilkinson as a third partner, on the grounds that, " rather than

only five per cent. but also large premiums for the use of capital thereof contrary to the laws against usury."—*Aris's Birmingham Gazette*, October 26, 1778.

[1] Boulton to Watt, July 11, 1778. Tew MSS.

[2] Boulton to Watt, July 25, 1778. Tew MSS.

[3] Watt to Boulton, August 8, 1778: " I send enclosed Draft of the Cornish Bank ' Elliot & Praed ' on their representatives in London for £386 10s. 0d., being ye amount of Ting Tang account with Mr. John Wilkinson paid by us to him." Tew MSS.

founder at sea, we had better run on shore."[1] This suggestion was not really acceptable to either partner, and towards the end of the year, Boulton tried to make arrangements with a Mr. Wiss for a loan of £7,000, in return for which Boulton & Watt were to pay him an annuity, guaranteed by the engine contracts. Neither Boulton nor Watt was anxious to mortgage or sell agreements, but as money looked like being " more scarce than ever it was known " in the coming winter, something had to be done.[2]

Mr. Wiss, who was a merchant, was not anxious to put away money in annuities, unless there was a distinct prospect of good returns, for which purpose he demanded the definite allotment to himself of various engines and their payments.[3] One of the difficulties in the way of completing the transaction was that Wiss wanted the money paid straight to him from the engine owners, and not through Boulton & Watt,[4] which was impossible,

[1] Watt to Boulton, July 8, 1778. Tew MSS.

[2] Boulton to Watt, December 17, 1778. Tangye MSS.

[3] Wiss to Boulton, November 7, 1778: " Considering the great value of money at this time, I would not choose to part with three or four thousand pounds on annuities, but upon the footing which yourself did propose, and to which I did acquiesce, adding only this, that for my security I shall be satisfied with your joint engagement of you and Mr. Watt's ensuring me the enjoyment of the income of the engines until the end of your privilege in the manner you do propose, viz. by making over others in case these should cease going; I beg that you will favour me with your answer directed for me at Genoa by way of France, as I have some money there which I might remove in case you should agree." Tew MSS.

[4] Boulton to Watt, January 20, 1779. Tangye MSS.

as it would have deprived the engine firm of the shadow of authority that it possessed.

During 1779 and 1780, the prospects did improve appreciably, though difficulties were found in the way of estimating the amount of coals burned and the amount of saving,[1] and Boulton began to advocate a fixed annual payment, instead of a variable amount based on Watt's tables of the saving. Watt, however, was tenacious of his tables, and was very disappointed when an agreement with the Wheal Virgin was concluded for a payment of £2,500 per annum.[2]

Moreover, the Cornish mines to which they supplied engines had, in some cases, ruined the people who already had shares in them, and the time taken to erect the engine and pump the water out was long enough to break up the companies.

Thus it happened in several cases that Boulton & Watt had to take shares in the Copper Mining Companies in order to obtain payments for their engines. Wheal Union Mine was one of the earliest of these ; its agent said it would be given up unless a new corps of adventurers be raised. " Mr. Edwards wishes we would take some shares . . . what strikes me this time is this—If the engine is stopped we gain nothing, if they will accept of our payments from the monthly savings we may venture to buy

[1] Boulton to Watt, February 1, 1777. Tangye MSS. Watt has invented an unalterable counter to register the strokes of the engine.

[2] Watt to Boulton, September 18, 1780: " I shall not depart from the tables." Tew MSS.

to that extent."[1] The snowball of capital was beginning to roll faster and faster, and more and more shares had to be taken in mines every year. Their share in Wheal Union was a sixteenth,[2] and by December, 1780, Boulton was engaged in five mines,[3] and, in 1782, he and his friends accounted for a quarter share in a mine[4]

[1] Boulton to Watt, April 19, 1780. Tangye MSS.

[2] Boulton to Watt, April 28, 1780. Tangye MSS.

[3] Boulton to Fothergill, December 11, 1780, Tew MSS. : "I have found it necessary to interweave myself into the general Cornish business, by which I am the better enabled to protect and encourage the engine business and profits. I am now become quite initiated into the mining and copper trade, and have embarked in no less than four different partnerships, and am upon the brink of closing another agreement of do., which will require much of my attention."

[4] A list of adventurers in Polgooth Mine is given by Boulton writing to Wedgwood, who was also a shareholder.

Mr. John Wilkinson	5	sixty-fourths
Mr. John Wedgwood	5	,,
Messrs. Boulton & Watt	5	,,
Mr. Capper	1	,,
Thos. Reid, Esq.	8	,,
Messrs. Shawle, Fox & Co.	4	,,
Francis Rodd	2	,,
Hy. Hawkins Tremaine, Esq. ..	1	,,
Chas. Rashley, Esq.	2	,,
Lord Arundale	1	,,
John Miers, of London	4	,,
Dr. Chas. Lettsome, M.D., London ..	1	,,
Walker, a Banker in London, with Milldred & Roberts	1	,,
Harford, Getley & Partridge, of Bristol	4	,,
Fox, Phillip & Fox	7	,,
Ed. Fox	7	,,
Wm. Flamock, St. Austell	1	,,
Thos. Moor	1	,,

that had not been worked for twenty-five years.[1]

The Cornish mines were curiously in advance of their times in their company organization. At the time when an ordinary partner in a trading company was liable to meet deficiencies in that company with all his property,[2] a Cornish mine was "subject to the Stannary Laws, so that if it should become a losing concern, an adventurer may withdraw, and is not liable to lose any more than the sum he advances, and as the accounts are publicly settled every month, you may from time to time see how the concern goes."[3] This was a long step toward a limited liability company. All these new commitments in the Cornish mines, though ultimately they brought in a return, were at the time a drain on the firm's resources.

Wiss pressed for a definite allotment of engines; Watt demanded frantically to be released from his personal bond to Lowe, Vere & Co.; while the hardware firm was gradually sinking under the weight of the engine business.

Wm. Padley, of Swansey	1	sixty-fourths
Hy. Lakes, St. Austell	1	,,
Capt. Painter	1	,,
A. B.	1	,,
	64	shares.

The classes of shareholders are worthy of notice. They consist in Boulton and Watt and their friends, the Cornish Landowners, Cornish Bankers, London Bankers, and the Cornish Mining Adventurers.

[1] Boulton to Capper, November 11, 1782. Tew MSS. Boulton is confident of the worth of the mine.

[2] Boulton to John Wilkinson, October 8, 1787. Tew MSS.

[3] Boulton to Wedgwood, November 30, 1782. Tew MSS.

Watt's argument in that matter was that Boulton had agreed to provide the capital, and he did not see why he should enter into bonds to guarantee an advance.[1] Boulton was in a very difficult situation ; large commitments, a reproachful partner, and two creditors pressing for repayments.

Fortunately, at this time he had received £4,000 for reels for the East India Company.[2] One thousand of this went to his partner in the contract, Rehe, and £3,000 Wiss retained until their affairs were settled. Boulton intended to repay the £3,000 to Lowe, Vere & Company, and get their release for half the £14,000 and obtain the release of Watt from his personal bonds, substituting the personal security of Boulton & Fothergill. In order to do this, Watt was to hand over to Boulton & Fothergill sufficient engines to meet the demands of the bankers, and in return to draw from Boulton & Fothergill one-third the value of £7,000, or to receive engines equal in value to such third.[3] Watt agreed that this was desirable, but saw numerous objections to assigning as many engines as Boulton suggested. He thought that such a general assignment could not fail to hurt their credit.[4]

However, Lowe, Vere & Company preferred to keep the inventor in the agreement if possible,

[1] Watt to Boulton, May 1, 1780. Tew MSS.

[2] Watt's *Memorandum of Boulton* : " Reels used in organizing silks . . . which Mr. Boulton undertook, and by the assistance of the late Mr. Rehe made considerable improvements in." Tew MSS.

[3] Boulton to Watt, April 10, 1780. Tew MSS.

[4] Watt to Boulton, April 13, 1780. Tew MSS.

and Watt told Boulton that if his release was impossible, all he demanded "was an absolute release of so much of the mortgage as is equivalent to the money obtained from Mr. Wiss."[1]

Boulton repaid Wiss £1,000 in May, 1780, and agreed to pay an equal sum in December, 1781 and 1782, thus reducing the annuity which had to be provided for him to £400.[2] When the agreement with Wiss was submitted to Watt, he was annoyed to find that it was a mortgage agreement between Wiss, and Boulton & Watt, whereas it should have been between Wiss, and Boulton & Fothergill, or Boulton alone. Watt was willing to assign any quantity of engines, provided "that sufficient is left to secure Lowe, Vere & Co., and that he was bound in no bonds."

The position was quite simple: Watt had agreed to provide the invention, Boulton the capital. Those were the terms of the partnership, but to an outsider this was not apparent, and the bankers were naturally suspicious of lending money to a firm only one of whose partners was to be responsible for repayment. In the middle of May, Watt wrote to Boulton, "I shall, therefore, only say this, that if my executing this deed cannot be dispensed with, I will do it, but will not execute any personal bond for the money, and would rather assign you all Cornwall on proper conditions than execute this."[3]

[1] Watt to Boulton, May 1, 1780. Tew MSS.

[2] Boulton to Watt, May 17, 1780. Tangye MSS. Watt to Boulton, May 17, 1780. Tew MSS.

[3] Watt to Boulton, May 19, 1780. Tew MSS.

The difficulty with the bankers was that if the engines that were assigned to them stopped working, their payments stopped too, and unless they could control Watt, they might not be recompensed. Therefore, Watt agreed to assign certain agreements to Wiss, and bind himself "in a command" with Boulton "to put another agreement of equal value in the place of it, if that mine should stop working, but that Mr. Wiss is to take your and Mr. Fothergill's personal bond in place of mine."[1] The capital difficulty was not so pressing for a little time, though the copying machine, which Watt had invented,[2] needed supporting and advertising.[3]

Although Watt was eager that Fothergill should take his place as a security, he made difficulties about lending his workmen to the hardware firm when they received a large order for more reels from the East India Company. He quite failed to appreciate, though he took for granted the fact, that the engine company was founded on Boulton & Fothergill's reputation.

Moreover, the development of the copper and tin-mines, consequent on the application of steam-power, increased the importance of the home production in the market, and in November, 1780, it was suggested by the hardware manufacturers of Birmingham, that a copper and brass works, with a capital of £50,000, be set up with Boulton

[1] Watt to Boulton, June 9, 1780. Tew MSS.

[2] This was the ordinary wet-copying process which Watt invented.

[3] Boulton to Watt, June 12, 1780. Tew MSS.

as manager to lower the price of copper and brass. Boulton, however, refused, and "recommended patience for 18 mo., as in that time there will, in all probability, be double the ore raised than at present in this country," due to the use of steam-engines.[1] In any case, it is doubtful whether Boulton could have found the time or the capital to have entered an undertaking of that description, while his own affairs were in such a critical state.

Watt's care for his own skin, ill health, and occasional reproaches, had made Boulton's position very difficult. It has been said that in a combination between an inventor and a capitalist, the capitalist "is generally in a position to get the best of such a bargain,"[2] but this was not true of Boulton's partnership with Watt, and in December, 1780, Boulton wrote to Fothergill, that he must either "quit this business here (Cornwall) in favour of Soho (and I must say I do not think Mr. Watt has either health or spirits to encounter with the wrangels we do and must constantly meet with) or I must quit Soho in favour of the engine business."[3] This was written when Boulton was disheartened; and things improved slightly, until in June, 1781, Boulton's debts were, "Day, £1,000; Messrs. Baskerville, £1,000; Messrs. Lowe, Vere & Co., and the Amsterdam (Wiss) debt on mortgage; and although I am now within one year of being tolerable easy in money matters, yet I

[1] Boulton to Watt, November 20, 1780. Tangye MSS.
[2] Marshall, *Industry and Trade*, p. 244.
[3] Boulton to Fothergill, December 11, 1780. Tew MSS.

am at this time so circumstanced as to be truly miserable." Watt has been again pressing Boulton to release him from the personal bonds in which he was bound to Lowe, Vere & Co.; Boulton has "received so much pain from Mr. Watt's repeated ungenerous behaviour to me on that account, that I am determined as soon as possible to wipe away all obligation to him."[1]

Thus the firm went on, the income gradually meeting the expenditure, but in 1781 more difficulties appeared. Though Watt had almost perfected his rotary motion, it was not yet either patented or on sale. The Cornish mines were, therefore, still the main objects of their attention; and here two difficulties appeared, the mines that had been worked were becoming poor and unprofitable, while those that were large and rich had in many cases been so long disused, that large amounts of capital would be required to set them going.

Chacewater had become so poor that the adventurers lost £300 in the month of July, 1781,[2] while to set North Downs to work would cost £20,000 to £24,000, and would take two years.[3] However, Boulton suggested taking a small share in all the newly started mines.[4]

[1] Boulton to Matthews, June 28, 1781. Tew MSS. Matthews was the firm's London representative, and later took over the banking of the firm.

[2] Watt to Boulton, August 16, 1781. Tew MSS.

[3] Watt to Boulton, July 10, 1781. Tew MSS.

[4] Boulton to Watt, July 24, 1781. Tew MSS. "I think in North Downs we might take 1/32. We may always venture our license against their money."

Boulton was gradually paying off his debts with regularity, when, unfortunately, in August, 1781, "the Dutch politicks kept back the mails," and remittances he had expected did not come to hand.[1] Moreover, a Dr. Moor, who owed them[2] money, failed, and Boulton had to leave London without reducing his debts to Lowe, Vere & Co., much to the annoyance of the bankers.[3]

Boulton, nevertheless, managed to make his peace with them, and by October they were again in a complacent humour. Fothergill was the next trouble that Boulton had to deal with. He was ill and tired of the long struggle. The main weight of the hardware business fell on his shoulders, and he obtained no profit from the time spent by Boulton on engine affairs. Boulton intended to make an ultimate settlement with Fothergill, and Watt urged him to be more careful that the engine business suffered no loss.[4]

Boulton wished to deal fairly with Fothergill, and thought that he should receive some benefits for the risks that had been taken.[5] Watt, on the other hand, does not see why Fothergill should profit from his invention.[6] "At any rate, a sum equal

[1] Boulton to Zach. Walker, August 10, (?) 1781. Tew MSS.

[2] Boulton to Watt, August 21, 1781. Tew MSS.

[3] Boulton to Vere, Lowe & Williams, August 30, 1781. Tew MSS. Watt to Boulton, October 15, 1781. Tew MSS.

[4] Watt to Boulton, September 6, 1778. Tew MSS.

[5] Watt to Boulton, February 11, 1782: Boulton had arranged to share the engine profits with Fothergill until they reached twenty thousand, a sum which Watt is sceptical of their ever reaching. Tew MSS.

[6] Watt to Boulton, February 13, 1782. Tew MSS.

to what you have at greatest outlay stood delivered for should be a sufficient compensation for the risk, which I think was never very great since the Act was obtained and all the prior sums you tell me were charged to your own account, and, in fact, I do not see Mr. Fothergill was very bound in law for any sums you advanced, and consequently the whole loss would have fallen upon you in case of failure, so that any compensation you are in equity obliged to make must be for the time you have abstracted yourself from the concerns of Boulton & Fothergill."[1]

The fact that Arkwright's patent had just been upset must, doubtless, have influenced their credit adversely at this time.[2]

Boulton was tired of Watt's complaints and desired that he should take over the accounts of Boulton & Watt. This Watt was pleased to do, and immediately tried to cut down expenses in the firm as he had tried to cut down his own private ones.[3] Moreover, instead of all the engine company's profits being paid into Boulton & Fothergill's account, they were to be banked separately in the Birmingham Bank, and then applied to wiping off the debt to Lowe, Vere & Co. Watt wished to be out of debt to the London banker rather than to settle up with Boulton & Fothergill. While Fothergill was naturally anxious for a repayment as soon as possible.[4]

[1] Watt to Boulton, February 11, 1782. Tew MSS.
[2] Watt to Boulton, July 16, 1781. Tew MSS., Daniels, *The Early English Cotton Industry*, p. 102.
[3] Watt to Boulton, March 9, 1782.
[4] Watt to Boulton, March 9, 1782.

However, both sides were eager for a settlement as Fothergill was leaving partnership with Boulton. The position as it was between the original hardware firm and the engine firm is carefully set out in a letter to Pearson, the cashier, "By our contract of partnership, all expenses whatsoever attending the business prior to the passing of the Act of Parliament—were to be placed to his (Boulton's) account solely. And also all expenses which might or may ensue in making experiments for the improvement of the engine were to be charged to him, and in return, such engines, models, etc., which were made for that purpose were to be and remain his property or part of his stock. Consequently he ought to be debited for the costs of the several engines which have been erected for the use of Soho manufactory—Boulton & Fothergill ought to be debited to Mr. Boulton for the value of the said engines, which were applied to the use of the manufactory, and also for their maintenance. All expenses which were incident to the making of engines for sale should be charged to respective engines.

"General expenses should be debited for interest of money rents, clerks, salaries, travelling expenses, etc., in the prosecution of the business, my personal account is, I believe, clearly stated except some claims against Mr. B., prior to 1775, of no great amount—

"Whether Mr. B. ought to pay the late charges of patents I leave to himself,—

"As money had been advanced by Mr. B.,

through B. & F., at various periods, and has been applied promiscuously to the purposes of experiments and trade, it will be necessary to deduct the first from the latter, according to their dates before the interest can be charged.

" It may perhaps appear hard to charge Mr. B's. part with the whole expense of experiments, etc., but when it is considered that upon that account he is allowed two-thirds of the profits, and that it is according to the tenor of our bond of partnership, I expect that the appearance of hardship will vanish ; at any rate I am ready to forgo any claim which does not, in the present state of the business, seem just and reasonable. . . .

" It is only with Mr. B. that I am in partnership. That he is bound to admit no other partner in his share without my consent under my hand and seal. That I never did consent to his dividing any part of the profits of this business with Mr. F. any longer than Mr. F. and he should remain in partnership, and that I agreed to on consideration of Mr. F's. enabling Mr. B. to give a greater share of his time and attention to B. and his business than he has in reality done, and in consequence of which so much of the business has fallen to my share to do, that I have been rendered very unhappy—the want of Mr. B's. assistance has been a loss of some thousands to B. & W., and I cannot pretend to foresee all the consequences."[1]

Unfortunately, Watt, in taking charge of the affairs of Boulton & Watt, had not only written

[1] Watt to Pearson and Buchanan, February 20, 1782. Tew MSS.

to Soho about the accounts, but also to Lowe, Vere & Co. In this letter, too, Watt made his own position and lack of responsibility quite clear, and, unfortunately, gave the bankers an opportunity of complaining about Boulton's handling of the transaction. Boulton immediately wrote to Watt upbraiding him, a letter which Mrs. Watt kept from her husband for some days. Watt apologized for his letter, but continued to complain about their debts, and said that he was sick of the engine business, and wished he were out of it. There are three ways in which the business can be saved, all of which entailed sacrifices on Boulton's part. His suggestions to Boulton are:[1]

> "First. If you can borrow upon bond or mortgage of any of your property, the sum you owe Lowe, Vere & Williams.
>
> "Second. If you can dispose of your property in the house of B. & F., even at the losing price.
>
> "Third. If you can find a proper person to buy so much of your engine property as will relieve you—J. Wn;[2] the Dale Co.;[3] or our friends, W. Phillips & Co.;[4] Mr. E."[5]

The main object of Watt's solicitude was his own emancipation from the personal bonds, and to do

[1] Watt to Boulton, March 16, 1782. Tew MSS.

[2] John Wilkinson.

[3] The Coalbrookdale Iron Co., and Messrs Reynolds & Rathbone.

[4] Another firm of iron smelters.

[5] Mr. Eglinton, in partnership with Boulton in the painting side of the hardware business. Boulton to Mathews, April 1, 1782. Tew MSS.

this, Boulton even tried to transfer the loan to another firm.

This certainly was the most difficult period of the engine business; the mines in Cornwall, the main source of income, were making difficulties about payment,[1] and the orders for engines had almost ceased to come in.[2] At the end of the financial year, 1781, Boulton & Watt had not "money to pay their Xmas balances nor their workmen's wages, but have had money from B. & F. on account for those purposes."[3] Then, in June, the position began to simplify itself. Fothergill died and Boulton made ample, even generous, provision for his family; the death of his partner simplified the financial affairs of the firms considerably.[4]

Money, generally, was easier, and Boulton thought that if he could only get rid of his present indebtedness, he could get half a dozen friends, who would lend him eight thousand pounds each.[5] The difficulties of the firm can be understood, for their net income from engines erected up to the end of 1782 was £3,724, whereas the payments, which ought to have been made had all the engines been at work, was £9,878.[6] However, money was beginning to

[1] Boulton to Watt, April 2, 1782. Tew MSS.
[2] Boulton to Watt, April 19, 1782. Tew MSS.
[3] Boulton to Matthews, June 19, 1782. Tew MSS.
[4] Boulton to Ingram, May or June, 1782. Tew MSS.
[5] Boulton to Matthews, July (17), 1782. Tew MSS.
[6] A list of engines compiled by Boulton, September 24 (1782). Boulton to Watt, May 31, 1783: "Mineing was a losing trade upon the whole like ye state lottery; yet nevertheless the few 5, ten, & twenty thousand pounds prises kept up the spirit of mining." Tangye MSS.

come in, and while Boulton was in London occupied with the foundation of a brass company and the opposition of a petition to Parliament, which sought to prevent the exportation of brass,[1] he received bills from Watt, in Cornwall,[2] which enabled him to reduce their debt to Lowe, Vere & Co. by £10,000, and at the same time to obtain Watt's conditional release from the personal bonds.[3]

Rotative engines were now being ordered and paid for by annual payments of £5 per unit of horse-power,[4] and the Albion Steam Corn Mill was founded by Boulton, Watt & Co., in London. This necessitated a further sinking of capital, Boulton investing £6,000 in that concern; but by this time the engine business was firmly on its feet, Watt, at any rate, was deriving an income from it, for in 1785 he ceased to draw his £330 per annum from Boulton & Fothergill, while in 1787, he was credited with £4,000 from Boulton & Watt,

[1] Boulton to Watt, May 24, 28 and 31, 1783. Tangye MSS.

[2] Watt to Hamilton, July 11, 1782: "The clear income of the engine business is above £3,000 per annum, and has a chance of being £2,000 greater, but may also be less or nothing; as we shall be able to defeat our opponents." Tangye MSS.

[3] Boulton to Watt, May 31, 1783: "I have pd. L. V. W. 10,000 of B. & W. money by the 2 bills you sent me and a draught on Matthews for the rest and they are to write you a letter to tell you that they agree to release you as soon as my account with them is reduced to eight mill., which I shall beg Mr. Walker to be attentive to the accomplish as soon as possible." Tangye MSS.

[4] Boulton to Morris, Iron Founder, October 21, 1786. Tew MSS.

and Boulton would have paid him the whole amount due had it not been for the demands of the Albion Mill.[1]

In 1784 matters were finally arranged with Lowe, Vere & Co., and Matthews took over the banking of Boulton & Watt.[2]

The crisis was passed, Boulton's credit and the real efficiency of the steam-engine had enabled the engine company to succeed in spite of the prejudice against the monopolies, the suspicion of wild-cat schemes, and the large scale of the enterprise. The extension in the size of the business had meant improved business methods in Cornwall. Boulton had introduced formal procedure into the Adventurers' meetings, and at Soho order and accuracy were everywhere insisted upon. The invention of a machine for copying letters, by Watt, was in direct answer to a demand; he was tired of copying long, wearisome letters, and they had made it a rule, from the foundation of the business, never to send a letter without copying it, and the machine saved many laborious hours. The internal business organization was a natural accompaniment of the expansion of industrial enterprise, and it is probable that the methods were copied to a large extent from those of the bankers and merchants; in fact, just as more and more capital was diverted from commerce to industry, so the methods of commerce were applied to industry.

[1] Boulton to Matthews, December 7, 1787. Tew MSS.

[2] Boulton to Matthews, December 16, 1784. Tew MSS.

Boulton, having successfully overcome all his difficulties, sought for new fields to conquer. He became the moving spirit of the Cornish Metal Company, which was to buy, smelt, and sell to manufacturers the copper and brass of Cornwall.[1] As this company consisted almost entirely of the manufacturers who consumed the brass and copper in their works, the result was the saving of a middleman, and the control of the preliminary stages of production by the final producers.

Boulton was asked to persuade his friends to advance money at 8 per cent for this venture, but he managed to obtain the loan of thirty or forty thousand pounds at a rate not to exceed 5 per cent from an Amsterdam banker, called Hope, who was also to take charge of a copper magazine at Amsterdam ; Mr. Hope, however, required a commission on his sales, and a quick return when the copper company sold their copper.[2]

Boulton's interests were changing. He advised that no further mines be opened in Cornwall, a sure proof that the engine business elsewhere was booming, and his interest in copper was that of a consumer, as he was tendering for a contract for a copper coinage, which the Government proposed

[1] Watt to Wilson, November 2, 1786. Tew MSS.

[2] Boulton to Wilson, November 2, 1786. Tew MSS.: " It is to be understood that the aforesaid loan is not to lye at interest for a number of years, because such a house as Mr. Hope's can always do better than live upon the simple interest of their money, but they will accomodate the Cornish Company until their sale come round."

issuing.[1] If he obtained the contract for the coinage, he would " be obliged to find the capital of twenty or thirty thousand pounds to carry it on with." The increased employment of capital in industry naturally united more closely the bonds between banker and industrial magnate. In 1788 Boulton was again hard up for money ; the copper companies to which he belonged, being combinations of producers, required that each shareholder should buy a certain fixed amount of copper,[2] and Boulton had forty tons of copper unused, and looked forward to being in great want of money, and it was difficult to obtain further credit, either in Birmingham or London. Boulton, writing to Wilson[3] about this tightness of money, says, " I dare not mention particulars at this moment more than to say that the very greatest manufacturers of Manchester have that in consequence thereof, some bankers in that neighbourhood are[4] and in consequence

[1] Boulton to Droz, May, 1787: " The Government proposed five hundred to ten hundred tons coined directly, but the Government will have nothing to do with the purchasing of the copper or with the circulating of the money." Tew MSS. Droz was a French artist whom Boulton proposed to employ to design the coins.

[2] Boulton to Townend, February 13, 1781: " A Capital of £20,000 to be employed in Brass and Spelter Works divided into two hundred shares, no person to hold more than four shares and every holder covenants to purchase from the company one ton of brass per annum for every share he holds, by which means you will perceive that the Company has made sure of a market for 200 tons of brass per annum." Tew MSS.

[3] Wilson was the agent of the steam engine firm in Cornwall, and had been indefatigable in their interests from the beginning.

[4] Among the firms which became insolvent at this date were Livesey, Hargreaves & Co., Calico Printers and Manu-

of such stoppages some great houses in London are in a very wretched condition, and I fear many failures will follow among the middle class of manufacturers and traders. An instance of which happened this morning in Birmingham. The commercial world now seems to be in as great agitation as it was in the year 1772, and I fear the effects will be more violent."[1]

However, Boulton had no need for alarm, the engine business was in a sound position, and continued to develop rapidly until the end of their period of monopoly,[2] and Boulton was enabled to stand as a representative of the manufacturers of the country on many questions. His pre-eminent position in the declining years of the eighteenth century proved the solidarity of his achievement for industry.

facturers, of Blackburn. The number of bankruptcies in the six months ending July 22, 1788, amounted to 360. "Allowing one thousand pounds to be sunk by each—how enormous must be the general loss sustained by the public in so short a space of time."—*Harrops Mercury*, July 22, 1788.

Leo H. Grindon, *Manchester Banks and Bankers*, 1877. One bank prevented a run by painting all its doors and woodwork, and the time wasted in getting into the bank paintless saved the situation. pp. 45–7.

[1] Boulton to Wilson, May 4, 1788. Tew MSS.

[2] *Inventions, Improvements, and Practice of Benjamin Thompson, Colliery Engineer, with some interesting particulars relative to Watt's Steam Engine*, 1847, p. 110. "In 1800 Mr. Watt's patent expired . . . many establishments for making steam-engines of Mr. Watt's principle were then commenced; but it would appear that the object principally aimed at was cheapness rather than excellence, for they fell short as to performance of the Soho engines, and Boulton and Watt for many years afterwards kept up their price and had increased orders."

For a "description of a very cheap engine for raising water" see *Nicholson's Magazine*, May, 1802.

CHAPTER VII

Capital in other Industries

(1) *Introductory*

The history of the capitalization of other trades is not so illuminating as that of the pioneer engineering firm. In the first place, London was the only town where the bankers had control over large capitals,[1] and, in many cases, appeal had even yet to be made from London to Amsterdam;[2] and the history of the connexion between one banking house and an industry must have been fairly typical. Moreover, in many industries large scale production and large capital could exist side by side with a small scale production and a very small capital,[3] but this was impossible in the steam-engine business, combined as it was with a monopoly.

However, it is worth noticing the development of capitalism in the potteries and the iron trades. Mining and canals were, even in Adam Smith's

[1] L. Grindon, *Manchester Banks*, p. 32. In Manchester in 1772 the Bankers' business consisted in simple money changing.

[2] Cunningham, *op. cit.*, Vol. II, p. 324. Boulton's loans from Wiss and Hope, both Amsterdam bankers and merchants.

[3] The potteries and the iron foundries were obvious cases in point among the non-textile trades v. *supra* pp. 45-9.

time, openings for joint-stock enterprise, and will be noted as such.[1]

(2) *Potteries and Wedgwood*

It is impossible in this last half of the eighteenth century to speak of an industry without also mentioning the name of the man whose energy made it successful. This may perhaps be unfair, as undoubtedly all these pioneer captains of industry owed more to the steady piling up of foundations by their predecessors, many of whom became insolvent in their efforts,[2] than has been acknowledged.

When Josiah Wedgwood completed his apprenticeship, in 1749, the pottery industry of Staffordshire was a small scale production, and though it was free from the rules of mediaeval organization, nevertheless, its status was that of an industry in the Middle Ages. Small potters produced small quantities of pottery for very limited markets.

However, the industry was already rapidly developing, while the mineral treasures of Staffordshire, which were to give the county its importance in the expansion that was to come, were already being actively worked. When he was still quite young, Josiah Wedgwood became a journeyman in his brother's potworks, and upon reaching twenty-one, was paid the sum of £20, which his

[1] Adam Smith, *op. cit.*, Vol. II, pp. 242-4. Scott has a defence of joint-stock companies against Adam Smith's strictures. Scott, *op. cit., passim.*

[2] H. W. Dickinson, *John Wilkinson, Ironmaster*, p. 8.

father had left him. In 1752 he entered into partnership with one Harrison, who had been an ordinary tradesman in Newcastle-under-Lyme, and supplied the capital. But as Harrison desired to appropriate the larger share of the profits, this arrangement soon ended, and Harrison was replaced by Thomas Whieldon.

From 1754–9 Wedgwood & Whieldon conducted a very profitable business, into which Wedgwood introduced many improvements. The expansion of the business and the increase of capital was gradual when compared with the increase of Boulton & Watt. In 1753 the debts of the earlier firm, in London, were only £291 12s. 7d., yet the balance sheets, which exist for the year 1757, show a steady increase of business.[1]

After five years' partnership, Whieldon retired from the pottery manufacture with a considerable fortune, and Wedgwood set up on his own account.[2] His capital must have been small, and consisted principally of the money he had amassed while Whieldon's partner, and the amount left him by his father and a Mrs. Egerton, both of whom mentioned Wedgwood in their wills.[3]

At first, Wedgwood restricted his manufacture to small articles of an ornamental kind. His chief difficulty was labour rather than capital. The workmanship of the potters, when Wedgwood

[1] Smiles, *Life of Wedgwood*, p. 34. The profits for January, 1757, are £3 16s. 7d., for May, £28, and for October, £36.

[2] *Ib.*, p. 39.

[3] Meteyard, *Life of Wedgwood*, Vol. I, p. 250.

started business, was slovenly and rude, and he had to educate his men to work with his improved materials on delicate pieces of ware.[1]

In 1761 Wedgwood extended his business by the very simple operation of hiring some more hovels and working sheds, and adding to his body of workmen. Then he began to insist upon specialization and the division of labour among his workpeople.[2] In 1762, while Wedgwood's business was still rapidly and steadily growing—for growth rather than expansion describes the development of Wedgwood's potteries—he was introduced to a Manchester warehouseman, called Bentley.[3] Bentley lived in Liverpool, and had gradually developed into a general merchant. It was customary for people, even though they were not merchants, to take "a venture" in out-going ships, and to speculate in articles which were put up to auction by those who had imported them. Dick Whittington is a celebrated case in point. It was natural, therefore, for a man like Bentley engaged in trade at sea-ports, such as Liverpool, Bristol, Great Yarmouth, or Hull, to drift almost unconsciously into the character of a general merchant.[4]

Bentley became Wedgwood's constant adviser and agent, first in Liverpool and later in London,

[1] Smiles, *Wedgwood*, p. 45.

[2] Meteyard, *Wedgwood*, Vol. I, p. 260.

[3] *Ib.*, Vol. I, p. 313.

[4] *Ib.* Boardman, *Bentleyana*, Liverpool, 1851, pp. 7, 10. Bentley was one of the early opponents of the slave trade in Liverpool. His name first occurs in the directory of that city in 1766 as a Manchester warehouseman.

which the expansion of the business soon made the most important centre for Wedgwood's trade. Wedgwood took out no patents for, as he said himself, a patent would have limited the public utility of his improvements.[1] He was soon restricted by the size of his works, and began to attempt addition and extension, but the neighbouring landlords declined to allow him more land. Therefore he was compelled to move his works to a spot two miles from Burslem, and near to the course of the projected Grand Trunk Canal. Wedgwood, who had always delighted to revive the forms of ancient vases and intensely admired the art of Roman and Greek pottery, called his new works Etruria.[2]

Bentley, who gave his advice on the new works, became a partner of Wedgwood's in 1766.[3] Latterly Bentley had been occupied almost entirely with earthenware, importing clay from Dorsetshire, Cornwall, and Devonshire, and exporting Wedgwood's productions to America and other countries. While the works at Etruria were in the course of construction, Wedgwood, whose business had almost inevitably expanded, had many conversations with Boulton on the subject of business organization.

Boulton explained to Wedgwood his book-keeping, his method of finance, his agencies, his system of

[1] Smiles, *Wedgwood*, pp. 76–80.

[2] *Ib.*, p. 86.

[3] *Ib.*, p. 88. "We are every day finding out some ingenious man or curious piece of workmanship; all which we endeavour to make subservient to the improvement of our taste or the perfection of our manufacture." Boardman, *op. cit.*, p. 15.

accounts, and all the other points of business organization that were developing his rapidly expanding business.[1]

But even Wedgwood needed more capital than he possessed—the cost of the new works exceeding the estimates by £3,000. The sum was so small, and the business so sure and so unspeculative, that the other money was easily obtained—and to a large extent from friends of Wedgwood, without recourse to the public credit of the banks. The pottery so far manufactured in Staffordshire was soft earthenware, the secret of making hard porcelain had been for ages confined to China. However, in 1707, a Saxon, called Bottgher, discovered the method of making it, and the Elector of Saxony seized him and kept him strictly guarded in order to organize a royal porcelain manufactory.[2] Great care was taken to preserve the secret, but without success, and by 1755 royal works were established in Vienna (1722), Berlin, St. Petersburg, Munich, and Sèvres (1755).

China clay was first discovered in England, in 1768, at Tregonnin Hill, in Cornwall. The discoverer of this deposit was William Cookworthy, who joined with Lord Camelford in a porcelain works. They were immediately confronted with the difficulty of obtaining coal for their ovens, and had to use wood. This was very expensive, and after obtaining a patent, in 1768, and spending over

[1] Smiles, *Wedgwood*, p. 134. Boulton to Wedgwood, July 10, 1767. Tew MSS.

[2] Smiles, *op. cit.*, p. 173.

£3,000 on the works, they transferred the undertaking to Richard Champion, of Bristol. Cookworthy's patent was extended, in 1775, for a period of fourteen years. This extension was granted in spite of the opposition of the Staffordshire potters, chiefly through the influence of Burke. It is curious to find Burke on two different sides with regard to this patent extension and that of Watt: the cases seem exactly parallel. Smiles states that Burke was again influenced by his electors, a doubtful assertion to make about Burke.[1] However, two years later, Champion closed his works, and sold his patent right to a company of Staffordshire potters.

Wedgwood's objections to this restriction by the patent were very strong. He did not believe in monopolies and never patented a single one of his inventions. In 1775 he managed to get hold of some china clay, to use for other purposes than porcelain, and a few years later he offered the King of Saxony £3,000 per year for the right of running the royal factory at Meissen, which was then making a loss. His offer was refused. Wedgwood made several journeys into Cornwall in his efforts to discover the best clays, and, if possible, to obtain control of the raw material of his industry.[2] He made journeys for this purpose in 1775 and 1781;

[1] Smiles, *op. cit.*, p. 179.

[2] Smiles, *op. cit.*, p. 190. "Having now completed our business in Cornwall by having got a firm and secure hold of the raw materials upon reasonable terms, we left Mr. Griffiths, our Agent, to conduct the business." This was in 1775.

on the latter occasion spending some time with Watt, who was then working in Cornwall.[1]

The pottery industry, given its initial impulse by Wedgwood, rapidly increased in size and wealth. The output of the Staffordshire potteries, in 1725, was under £15,000 in value, whereas, in 1777, it had increased fivefold, and, in 1785, there were 200 master manufacturers employing 20,000 persons, engaged in the industry. This development was largely due to the presence of coal and clay near together, and to the existence of a man like Wedgwood capable of developing a large manufacture. He introduced specialization and a hitherto unheard of division of labour. For a long time he combined the functions of employer and merchant and foreman, and he represents the intermediate stage of paternal employer between the gild master and the pure capitalist.

The difficulties of the period and the unknown depths of economic organization, had their effects upon the potteries. Wedgwood's efforts to obtain control of the raw material and his improvement in transport to his markets, show how afraid the manufacturers were of the increasing distance that separated the raw material from the consumer.

(3) *Wilkinson and the Iron Trade*

The state of the iron trade immediately previous to the introduction of smelting with coal was one of decay.

[1] Watt to Boulton, October 18, 1781. "Mr. Wedgwood has been here in this country some days hunting clays and soap rocks, cobalts, etc." Tew MSS.

In 1740 the three hundred blast furnaces mentioned by Dud Dudley, if they had ever existed, were certainly cold. The total production from all the fifty-nine furnaces then in blast was, at that date, only 17,350 tons.[1] Recourse was had to foreign markets for the necessary supply of iron, and the immense annual importations from Russia and Sweden may be said to date from this period. The imports rose from an average of 15,642 tons, in 1718, to 34,072 tons, in 1755.[2] However, the developments of improved blast, and the example of Dr. Roebuck, at Carron,[3] and the Darbys, at Coalbrookdale, in using coal to smelt with, altered the position. The iron trade rapidly revived and the assistance of the double acting steam-engine made coal-smelting a matter of great ease. The general use of pit-coal unquestionably occasioned an earlier relinquishment of many of the charcoal works than would otherwise have been the case, but the manufacture has so immensely increased, as to render this a matter of slight importance.

In 1778 the production of charcoal pig-iron in England was 13,100 tons, while that of coke pig-iron was 48,300 tons. The output of Shropshire alone, by the latter method, was 23,100 tons.[4] This very rapid increase is, to a large extent, due to the efforts of John Wilkinson and, in a lesser degree, to the Reynolds and Darbys, of Coalbrookdale.

[1] Scrivenor, *History of the Iron Trade*, p. 57.

[2] *Ib.*, p. 58.

[3] *Vide supra*, pp. 77-9.

[4] R. Meade, *Coal and Iron Resources*, p. 831.

Wilkinson was well on the way to success before his connexion with Boulton & Watt and the steam-engine, but this association was the most important fact in his career. The steam-engine was first applied to his iron-works, and the rapid and increased effects of this application were soon felt in most of the iron districts. The produce of the furnaces was greatly increased as to the quantity of metal, and as the proprietors of the existing works became more prosperous, other capitalists were induced to engage in similar undertakings.

Though in some cases foreign iron was preferred, yet the high price of it and the difficulties made by the Russians, who thought we were quite dependent upon them for our supply of iron, restricted the demand for imported iron. New works were rapidly erected, and between 1788 and 1796, the production of pig-iron was doubled. In 1796 the production of iron was 125,079 tons, and the furnaces numbered 124, while in 1806 a parliamentary return gives the output of 161 furnaces as 243,851 tons. The production having again doubled in ten years.[1]

This was, beyond doubt, due to an increase in demand and an improvement in supply. Both of these can be summed up in one word, "steam-power." Steam-power made coal-getting easy, and provided an adequate blast for smelting with coal, while, on the other hand, steam-power created a large demand for iron, for the manufacture of engines, and machinery of all sorts. In both these

[1] *Ib.*, pp. 832–3.

fields of expansion Wilkinson played a great part. In 1796 the produce of his iron-works alone was 15,274 ; about an eighth of the total output of the country. The Reynolds' and the South Wales iron masters followed in his footsteps.

It was an industry that, in the first place, could be easily developed by an energetic man. When Wilkinson found it, the iron industry consisted in a number of scattered furnaces depending upon a supply of fuel that was decreasing rapidly in quantity. The small iron-works which he controlled were easily developed without the help of credit agencies or outside capital. The scale of the industry was gradually increased by the improvements which he introduced, and the developed demand for iron.

CHAPTER VIII

The Penetration of Industry by Steam-Power

The history of the firm of Boulton & Watt is interesting for another reason. From 1775 to 1800 they possessed a monopoly of steam-engine construction,[1] and, therefore, their output comprises practically all the engines that were erected in Great Britain before the year 1800. The records of the firm contain the dates, power, and owners of all engines erected, therefore it is comparatively easy to discover which trades employed steam-power, and to what extent.

This is important in any history of the growth of capital, since any business that could afford the initial cost of the erection of one of Boulton and Watt's engines must have possessed a large amount of capital. Moreover, the capitalist nature of such businesses is confirmed by the fact that they were able to use power on a large scale, and could afford to lock up their resources in fixed capital.

The history of the introduction of the steam-

[1] Watt's ever-active genius kept on patenting improvements so quickly that evasions and imitations were incapable of being successfully worked. Seven new patents were taken out before 1785.

engine into industry falls into two obvious and natural parts. The first of these extends from the earliest Newcomen engine to October 25, 1781, when Watt patented his rotary motion and the second period began.

It is very difficult to find out exactly how many of the old atmospheric engines were in use in England before Watt invented the separate condenser. Newcomen, himself, probably only erected about six or seven. An advertisement in the *London Gazette* for August, 1716, says, "that there are diverse engines of this invention now at work in the several counties of Stafford, Warwick, Cornwall, and Flint."[1] The use of these engines spread rapidly, especially for coal-mines in the Newcastle district. A certain William Brown, of Throckley, on the Tyne, began to erect engines in 1756, at which date, an engine was still "a great rarity," and from 1757–76 Brown personally supervised the erection of twenty-four engines, mostly in the Newcastle district.[2]

When Smeaton turned his attention to steam-engines, he attempted to compile a list of atmospheric engines then existing, making a very careful investigation of the one erected by Newcomen, or, probably more accurately, by his partner, Calley, in 1717, at Austhorpe, where Smeaton lived.[3]

Smeaton collected a list of a hundred engines that had been erected on the Newcastle coal-field,

[1] *London Gazette* for August 11–14, 1716. *Vide supra*, p. 38.
[2] Galloway, *Annals of Coal-mining*, pp. 260–261.
[3] *Ib.*, p. 242.

or near it, since the beginning of the century.[1] By 1769, he says, that many of these had been worn out and given up, but those that were then in action amounted to fifty-seven, of a probable horse-power of 1,188. Smeaton, however, suspected their performance to be very small compared with their dimensions, and their consumption of fuel to be very great.[2]

In Cornwall, he says, that there were, in 1770 about eighteen large engines, that is engines with 60 in. cylinders, but these were probably not all the steam-engines then in use in that county, for a Cornish estimate puts the number of engines erected between 1740 and 1777 at sixty.[3] Many of these, like the northern ones, were, no doubt, disused, which would account for the smallness of Smeaton's total.

Moreover, in London, which had had an organized water supply since the fourteenth century, steam-engines were used to raise the water from the Thames or other streams to the houses, and there were about ten engines so employed in 1775.[4]

[1] Farey, *Historical Account of the Steam Engine*, pp. 233–4. Galloway, *op. cit.*, pp. 261–2.

[2] Farey, *op. cit.*, p. 237.

[3] *Victoria County History, Cornwall*, p. 549. Quoting Pryce, *Mineralogia Cornubiensis*.

[4] Scott, *Early History of Joint-Stock Companies to* 1720, Vol. III, pp. 15, 32–3, 35–9. Farey, *op. cit.*, p. 256. London Bridge Water Company used one engine to pump water from the Thames. York Buildings Company, which numbered water supply among its manifold activities, had an engine in 1725, which was re-erected in 1757. Shadwell Company had two, while rather later in 1770 an engine was erected by the Borough Company. Engines were also tried at Newcastle and

These were the main uses of such engines as can be traced. There were several used for returning water to drive water wheels, which, in turn, blew furnaces or drove mills, and at least two engines were exported besides the French one already mentioned. One of these was built at Carron, under Smeaton's direction, and was sent to Cronstadt to help to pump water out of one of Peter the Great's new dry docks, and the other was sent to Rotterdam to drain 7,000 acres that were under water.[1]

Smeaton and Brindley had each designed some of these engines ; but the latter had soon abandoned engine building, in favour of surveying and canal construction, just as Watt abandoned canals for the steam-engine. Smeaton, however, spent a great part of his energies on evolving a successful and more economical steam-engine, and even before Watt's invention of the separate condenser, had largely improved the performance of the atmospheric engine. His best engines were at a London water works and at a Cornish mine.[2]

Thus it would appear that the maximum number

York, two of the few provincial cities with an efficient water supply at this date.

Boulton to Watt, January 26, 1775. Muirhead, *Mechanical Inventions of Watt*, Vol. II, p. 80. Smeaton had erected an engine for the New River Company, and Chelsea had two in 1775.

[1] Farey, *op. cit.*, pp. 262–96. Three engines returned water to blow furnaces and four to drive mills ; among the latter were two at Coalbrookdale.

[2] Smiles, *Brindley*, pp. 148, 152 ; *Smeaton and Rennie*, p. 162.

of engines of the old type working, in 1775, was :

Newcastle district	60
Other coal-mines	10
Cornwall	30
London water-works	10
Other purposes	20
Total (approximately)	130

All these were working very expensively and intermittently. The first pumping engines, then, had been of use mainly in mines, which was the purpose for which they had been invented, and they were also being used for pumping water in water-works, in brine works, and to feed streams that drove the water wheels of mills. The rotary engine, on the other hand, could be used for everything, and enabled regular and cheap power to be applied to all industrial undertakings. When it was announced that Boulton was to become a partner in a new and improved steam-engine, in 1771, immediately applications and inquiries for engines were received from Cornish copper mines, the York Buildings Company, which supplied Piccadilly with water, and a mining company in Derbyshire.[1]

Then, when the partnership was finally fixed up and they started to get orders, these were the main types of enterprise for which engines were supplied.

[1] Smiles, *Boulton and Watt*, p. 153.

The first engine erected was that constructed at Kinneil, and was employed to return the water to the mill, at Soho, and thus to assist in driving the works by water-power.[1]

The next engines were built at Soho and Broseley, one for the Bloomfield Colliery[2] and one for the Broseley iron-works, to blow the bellows, for which purpose the reciprocating engine was also well fitted. Then followed a pumping engine at Hawkesbury Colliery, and one for Messrs. Cook & Co.'s Distillery, at Stratford-le-Bow.[3]

This was the output of the first year, and for these purposes the reciprocating engine was ideal. However, inquiries reached Soho for engines for other purposes. In June, 1775, Samuel Rowe, of Macclesfield, inquired about a "Steam-wheel for the purpose of turning a Silk Mill," which was then being turned by horse-power. Boulton replies that they have a rotative engine, but, as yet, they cannot be very precise about it.[4]

John Collet, of the Glass House, London, inquired for a "Steam-wheel applied to the turning of laps and grinding of stones for the polishing of steel work," and was met with the same indefinite

[1] Watt's *Memorandum of Boulton*. Tew MSS.

[2] *Ib.* Boulton to Watt, July 25, 1776. Among the early inquiries there were also a considerable number from distillers, few of which materialized. Tangye MSS.

[3] Watt's *Memorandum on Boulton*. Tew MSS.

[4] Boulton to S. Roe, June 29, 1775. Tangye MSS. See also Appendix, pp. 236-7.

answer.[1] However, in November, 1776, an inquiry from a Sheffield firm that required a rotary motion is answered by a suggestion, that until the rotary engine is perfected, a reciprocating engine be used to raise the water and drive the machines by water-power, as at Soho itself.[2]

Thus it appears that not only were the mining and other works that required pumping and blowing engines eager for steam-power, but also the generality of works that already possessed machinery driven by power.

The inquiries increased rapidly from about ten, in 1775, to twenty, in 1776, until in May, 1778, Boulton & Watt were refusing to accept orders for engines to be begun before 1779.[3]

Though inquiries came from all types of industry, the orders which were executed were mainly for mines,[4] water works,[5] brine works,[6] feeding canals,[7] distilleries,[8] and feeding water-wheels.[9]

In February, 1777, Watt gives a list of engines then working :

[1] Boulton to Mr. J. Collet at the Glass House, Cockspur Street, London, October 18, 1775. Tangye MSS.

[2] Watt to Messrs. Proctor & Beilby, Sheffield, November 8, 1776. Tangye MSS.

[3] Boulton to Hodgkinson, New Burlington Street, May 8, 1778. Tangye MSS.

[4] e.g. J. Scott, Shrewsbury. A coal-mine.

[5] e.g. Shadwell Water Works.

[6] e.g. Mr. Salman, Hassel, nr. Laughton, Cheshire.

[7] e.g. Birmingham Navigation.

[8] e.g. Messrs. Cooke & Co., Essex.

[9] e.g. Soho.

Cylinders	Place	Pump	Height of Water Raised
18 inch	Soho..	18½ inch	24 feet
50 „	Bloomfield Colliery (14 miles from B.)	14½ „	85-112 yards
38 „	New Willey, Shropshire	Blows two large iron furnaces	
*18 „	Stratford - le - Bow, Essex	15 inch	36-38 feet, as tide affects it
58 „	Bedworth, nr. Coventry	14½ „	130 yards high
	(Not finished, but will be going next week)		

* Only one which burns Newcastle coal.[1]

These types of engine, then, provided the main business of the firm until the invention of the rotary engine, with its "sun and planet motion," in 1781. The largest number of engines, however, was erected in Cornwall, where the necessity for them was greatest.

The difficulties which the copper miners had to overcome, and the dangers attendant on the flooding of the mines by water, had had a very discouraging effect on the enterprise of the Cornish mining adventurers, and many mines were allowed to go out of work because those who held shares in them decided not to throw good money after bad. In this position they were naturally unwilling to spend large sums on new engines, whose success in clearing the water was, at any rate, doubtful, if not impossible. Thus, though Boulton & Watt

[1] Watt to Wm. Chapman, Newcastle-on-Tyne, February 22, 1777. Tangye, MSS.

received inquiries from Cornwall, the orders did not mature. In 1776 they decided to erect one engine free of charge, to be sold to the adventurers if successful.[1]

This was, therefore, done on an adit in the Chacewater mine in 1778, and, proving entirely successful, brought an immediate rush of Cornish orders, with which the firm were largely occupied for the next three years, erecting five engines in 1781 for the Consolidated Mines.[2] The engines erected before the end of 1782 were all reciprocating engines, and Boulton compiled a statement of engines, and their conditions, in September 1782 which is of importance and worth quoting in full:

Position of Engine	Purpose	Remarks	Present Income £	Total Income when at Work
Cornwall—				
United Mines	Pumping (Copper mine)	At work, but B. & W. have given up their share of the savings for 6 months from April last ..	—	£1,000
Dolcoath ..	,,	At work	720	720
WhealUnion, now Castle Addit Mine	,,	,, ,, ...	300	300
Ting Tang, now Scorrier	,,	Was £200, is now £150. Will be at work in a month ..	150	150
			150	150

[1] Watt to Jonathan Hornblower, Senior, November 8, 1776. Tangye MSS.

[2] Watt: *Memorandum on Boulton.* Tew MSS.

Position of Engine	Purpose	Remarks	Present Income £	Total Income when at Work
Cornwall—				
Hallamanin	Pumping (Copper mine)	Will be at work in a month or six weeks	—	120
Wheal Chance	,,	On account of the poverty of the mine B. & W. have abated one-third of their share of the savings	400	600
Tresavean..	,,	At work	70	70
Whl. Treasury	,,	.. .. ..	—	150
Whl. Crenver	,,	At work	200	200
Poole ..	,,	At work, and pays from May	400	400
Whl. Virgin in the west	,,	In the same state with Whl. Virgin mines	—	100
Poldice ..	,,	Can only be set to work when the consolidated mines set to work	—	1,500
Trevaskus..	,,	Now erecting ..	—	100
Consolidated Mines of Whl. Virgin	,,	Engines are erected but they will not set to work till the price of copper is advanced and the price of coals lower and certain of being supplied ..	—	2,500
Polgooth ..	,,	Engines not yet begun to be erected ..	—	200
Chacewater.	,,	At work	300	300
Derbyshire—				
Gregory Mine	Pumping (? mine)	This engine will pay better in a year or two than it does now	100	100

Position of Engine	Purpose	Remarks	Present Income £	Total Income when at Work
Warwickshire— Hawkesbury Mine	Pumping (Coal mine)	At work	217	217
Northumberland— Chapman's, Newcastle-on-Tyne	,,	At work	73	73
Shropshire— Reynolds, Ketley	Blowing Iron works	At work	240	240
Yorkshire— Hull ..	Water works	At work	20	20
Wales— Penryndee, Carnarvonshire	Copper mine	At work, but wants repairing	100	100
Middlesex— Shadwell, London	Water works	At work	84	84
Chelsea, London	Water works	At work	130	130
Shropshire— Scott's two engines, Shrewsbury	Pumping (Colliery)	The large engine has been removed and will be reduced from £120 to £50 ..	50	50

Position of Engine	Purpose	Remarks	Present Income £	Total Income when at Work
Ireland— Colclough's engine	Pumping (Colliery)	Engine now erecting	—	84
Yorkshire— Walker's engine, Holmes Iron-works, Rotherham	Blowing Iron works	" "	—	50
Shropshire— Coalbrookdale. Reynolds	"	" "	—	150
Scotland— Wanlockhead, Edinburgh	Pumping Colliery	At work	100	100
Staffordshire— Wren's Nest, Dudley	"	At work	70	70

Moreover, in addition to those engines from which they expected to derive an annual revenue, there were several that had been sold outright, and those for John Wilkinson, for which he was to pay in coals only.[1] These engines can be traced in the

[1] Watt to John Wilkinson, July 17, 1777: "We will grant to you and your successors our Licenses to use the two engines now erected at New Willey and the one you propose to erect at Wilson House as well as a devil to be erected where you please during the remaining term of our exclusive privilege upon payment of one shilling yearly when demanded, provided you do not remove them to situations where coals are of much greater value." The payment for his engine at Snedshill he

letter books and engine book of the firm :[1]

Bloomfield Colliery, Tipton, Staffordshire.
Pumping (Colliery). At work.

John Wilkinson's engines.

1. New Willey[2]
2. Snedshill
3. Bradley
4. Snedhill, Shropshire.

} Blowing iron-works. At work.

Cooke & Co., Distillery, Stratford-le-Bow, Essex.
Pumping water. At work.

Richmond Water-works, Surrey.
Pumping water. At work.

Perier's engine, Paris Water-works, France.
Pumping water. At work.

Coleville's engine, Torrybourn, Scotland.
Pumping (Colliery). At work.

Salmon's engine, Lawton Salt Works, Cheshire.
Pumping brine. At work.

Birmingham Canal Company :

1. Smethwick
2. Spon Lane

} Feeding the canal. At work.

Thus in 1782 the distribution of Boulton & Watt's steam-engines was not very great The London water companies had adopted it of necessity, as had the Cornish copper miners. Engines were also working in isolated pits in the Scotch, Shropshire, and Staffordshire coal-fields. While at the iron-works of John Wilkinson, the Reynolds, and the

was to make in coals, which, "if they are of no value, you certainly can afford to pay them." Tangye MSS.

[1] See Engine Book, 1774–82. Tangye MSS.

[2] Broseley.

Walkers, in Shropshire and Yorkshire, they were being used for blowing the furnaces, and by their increased power were making a complete success of iron smelting with coal.

However, with the satisfaction of the Cornish demand, the orders began to fall off again. From the above list of Cornish engines it is obvious that the chances of many further mines in Cornwall being set to work was small. Moreover, Boulton & Watt only received payment as long as the engines worked and used coals, and, therefore, they had to be careful not to erect so many engines that the copper market would be flooded. However, in January, 1782, Boulton hopes to make a profit by the Cornish engines alone.[1]

The circumstances were less favourable since Boulton & Watt were not anxious to erect engines at coal-mines, as the method of payment depended on the price of coal, and as coal at the pit-head was very cheap, the savings were correspondingly small.[2] This reduced the sphere of the steam-engine to water-works, and there were comparatively few of these outside London.

Manchester and Salford did not possess a water-works company till 1808,[3] while Birmingham had to wait till 1826[4] for public water-works. There

[1] Boulton to Matthews, January 11, 1782: "The profits arise every minute . . . if I can keep the present Cornish Battery of 21 great guns going I have no doubt but I shall soon vanquish all my difficulties." Tew MSS.

[2] Boulton to Garbett, February 18, 1776. Tangye MSS.

[3] The conduit ceased to flow in 1777. Axon, *Annals of Manchester*, p. 104, 140.

[4] *British Association Handbook, Birmingham*, 1913, p. 183.

was no great demand for engines for public water-works, and the small engines which were to supply private houses with water, were "small Gimcrack things," that hardly repaid erecting, for there was no standardization, and they had to be sold outright. The use of the engine for furnaces and forges was also very limited, for, as yet, the great majority of the iron was smelted by small capitalists still using wood as fuel, and who worked in localities where such power as was necessary could easily be obtained from streams and water-wheels.

It looked as though the making of steam-engines was not to be the profitable business it had promised to be. The rotative engine was patented, in 1781, and of the five or six methods of producing rotary motion mentioned in the specification, the one which Watt decided to adopt was one which had been invented some time before, but only included in the patent at the last moment.[1] It was known as the Sun and Planet motion, because an arrangement of two wheels, one rotating round the other, was utilized to avoid using the crank, which, though well known for centuries, had been patented by one Washborough, who was also endeavouring to build an engine.[2] Even though he had spent so much time over the rotary engine, Watt was more interested in it for scientific reasons than from hope of profit. When difficulties were growing in Cornwall and closing the mines, Watt wrote to Boulton: "My inclination and feelings would lead me to

[1] Watt to Boulton, January 3, 1782. Tew MSS.
[2] Watt to Boulton, November 19, 1780. Tew MSS.

abandon both Cornwall and Wheal Virgin forthwith, and to attend to and amuse myself with these rotative machines, etc., but it would be dropping the substance to catch at the shadow: I have a very mean opinion of the rotative profits, and the trouble with each of them must be at least double that of an engine which raises water."[1]

Boulton, however, was more hopeful. In April, 1782, orders for engines had practically ceased, but Boulton was confident of their success, if only the mills would take up the engine.[2] He was ready with an answer to Watt's complaints that mill engines were all small ones, and suggests that mills offer a more permanent source of business "than these transient mines," and the difficulty of small engines could be curtailed "by making a pattern card of them . . . and confining ourselves to those sorts and sizes."[3] This is the beginning of standardization in engineering, and an important step forward in the firm's history.

Applications for mill engines soon began to come, among them was a steam corn-mill required for the Commissioners of the Victualling Office, to be erected at Portsmouth, and a scheme for drying gunpowder by some steam machine.

As orders for rotatives at this date were coming in very slowly, Boulton conceived the idea of a steam corn-mill, in London, to advertise the new engine. This was in 1783, but the London capitalists

[1] Watt to Boulton, January 23, 1782. Tew MSS.
[2] Boulton to Watt, April 19, 1782. Tew MSS.
[3] Boulton to Watt, December 7, 1782. Tew MSS. Boulton to Matthews, Jan. 11, 1782. Tew MSS.

were averse from the undertaking, and the engine firm had to find the greater part of the capital.[1] However, sufficient shareholders were got together, and a charter of incorporation applied for, but owing to the strenuous opposition of the millers, it was refused. Boulton made out their case in a letter to Matthews, which is interesting as showing the attitude of a trade, which was perfectly satisfied with the power it was already using (i.e. wind and water), to the new steam-power. He says, "it seems the millers are determined to be masters of us and ye publick. Amongst other arguments that may be urged on our part are ye following, viz.:

"(1) That we are limited in our capital, in our Warehouse room, and in the number of our Millstones, which shows we do not aim at that unbounded power they are so much inclined to.

"(2). ——

"(3). That Mills which are near Town, and have water carriage, cannot be much affected by our plans.

"(4) That one porter Brewery burns much more than half the Coals which all our three engines will do, and makes as much or more smoak than all of 'em will do, from the difference of their and our method of burning coal.

[1] Boulton to Watt, December 19, 1783. Under the law as it then stood liability under partnership was restrained by a special Act of Parliament. Tangye MSS.

Thorold Rogers, The Joint-Stock Principle in Capital, *Industrial and Commercial History*, p. 143.

"(5). That putting a stop to Fire-engine Mills, because they come in competition with water mills, would be as absurd a measure as stopping navigable canals, because they interfere with the Farmers and Wagoners. The agreement extends also against wind and tide Mills, or any other means whereby corn can be ground in London, for that is ye grievance these millers complain of.

"(6). That the same argument would extend to the stopping machines, whereby men's labour is saved, because it might be argued that men were thereby deprived of a livelyhood, and may, with as much propriety, be extended to the annihilating of water mills themselves, and thus go back to the Grinding of Corn by human labour."[1]

In spite of the goodness of their case, the vested interests of the millers were too strong for the steam-engine firm, and the charter of incorporation, having been refused, the Albion Mill was floated as an ordinary partnership. The interior machinery of the mill was designed and fitted up by the famous engineer Rennie. Watt was doubtful about the venture, as he feared that it would be a loss unless a good manager was obtained.[2] However, the mill was eventually set to work, in spite of difficulties

[1] Boulton to Matthews, April 30, 1784. Tew MSS.

[2] Watt to Boulton, March 28, 1786: "A few hundred a year should not stand in the way if a proper man can be found, such a man as Goodwyn the Brewer, or Galloway or Stonard the Starch maker." Tew MSS

with the workmen, who preferred to take orders from Watt rather than from Rennie.[1]

As soon as the mill began to buy corn, the corn market became very confused. To start the mill, they required 1,500 quarters of wheat, and "the report of the Albion Mill buying soon ran round the market, and raised the price 1s. per quarter at least."[2] The farmers, however, were pleased with the mill, and brought their corn and wished to exchange it for coals.[3] In May, 1786, the mill was finally set to work, and the London millers were much frightened at its doing so well. The effect of this on the Corn Market was curious, causing a fall in price to 35s. and 36s. per quarter.[4]

However, the mill was not a real commercial success, though it succeeded in demonstrating the capabilities of Watt's double rotative engine, and in attracting many orders from the London districts. It is possible that in time the mill might have been a success as its trade was, for the period, immense.

In a week it could grind sufficient for the weekly consumption of 150,000 people.[5] But just as its prospects began to brighten, it was burnt down by incendiaries on March 3, 1791. The main cock of

[1] Boulton to Watt, April 15, 1786. Tangye MSS.

[2] Boulton to Watt, March 15, 1786. Tangye MSS. It is noteworthy that the darkness and dirtiness of the inside of the mill were to be counteracted by whitewashing.

[3] Boulton to Watt, March 22, 1786. Tangye MSS. Boulton to Watt, June 12, 1786. Tangye MSS.

[4] Boulton to Watt, May 1, 1786. Tangye MSS.

[5] Boulton to Matthews, December 7, 1787. Tew MSS. The mill was a constant drain on the steam-engine firm, and was constantly making calls.

the water cistern was fastened, the hour of low tide chosen, and the mill was burnt to the ground.[1]

The orders that now began to come in more and more rapidly, were for engines to be used in all kinds of industry, and all over the country. The whole output of the firm is included in its letter-books and engine books, and the following lists are the result of a careful study of these papers.

It must be borne in mind that the output of Boulton & Watt represents the entire steam-engine building of the country, if not of the whole world; the pirated engines, that caused the firm so much anxiety and litigation, were not great in numbers, and the atmospheric engines, even as improved by Smeaton, were costly and inefficient,[2] and ceased to be erected.[3] The following tables throw a light on the capital of many trades, though caution is needed in making deductions from them, mainly owing to the fact that nearness to coal-fields and price of coal were important factors in many cases.[4]

[1] The criminals were never discovered. The loss was £10,000, of which Boulton held £6,000 and Watt £3,000.

[2] *Victoria County History, Cornwall*, p. 549. In 1782 twenty-one Boulton & Watt engines had been erected in Cornwall, and only one atmospheric Newcomen engine remained, that, too, disappearing in 1790.

[3] Watt to Wilkinson, April 16, 1778. Tangye MSS. Smeaton visited Soho and tried the engine to be erected for the Birmingham Navigation Company, and in consequence surrendered up the building of an engine at Hull to Boulton & Watt. Previously he had been very sceptical about the engine. He said it was too complicated for workmen to erect or manage.

[4] A firm that could afford a steam-engine was obviously a capitalist enterprise; but it should be noted that the superiority of Watt's engine was less important on the coal-fields where coals were of little or no value.

TABLE I

ENGINES ERECTED IN ENGLAND BY BOULTON & WATT between 1775 and December 31, 1785

COUNTY	Cotton Mills	Canals	Collieries	Water Works and Distillery	Copper Mines	Foundry & Forge	Corn Mills	Breweries	Potteries	Rolling Mill	Starch, Oil, etc.	TOTALS
	E. H.P.	E. H.P.	E. H.P.	E. H.P.	E. H.P.	E. H.P.	E. H.P.	E. H.P.	E. H.P.	E. H.P.	E. H.P.	E. H.P.
Cheshire ..	—	—	—	—	—	—	1 14	—	—	—	—	1 14
Cornwall ..	—	—	—	—	21*420	—	—	—	—	—	—	21 420
Derbyshire ..	—	—	—	—	1 20	—	—	—	—	—	—	1 20
Essex	—	—	—	1 5†	—	—	—	—	—	—	—	1 5
Middlesex ..	—	—	—	4 73	—	—	1 20	1 4	—	—	—	6 97
Northumberland	—	—	1 *20	—	—	—	—	—	—	—	—	1 20
Nottinghamshire	2 9	—	—	—	—	—	—	—	—	—	—	2 9
Shropshire ..	—	—	2 *40	—	—	8 261	—	—	—	—	—	10 301
Staffordshire ..	—	3 71	1 *20	—	—	6 74	—	—	2 16	—	—	12 181
Surrey	—	—	—	1 5	—	1 10	—	—	—	—	3 26	5 41
Warwickshire ..	—	—	1 *20	—	—	—	—	—	—	—	—	1 20
Worcestershire..	—	—	—	—	—	—	—	—	—	1 10	—	1 10
Yorkshire ..	—	—	—	1 10	—	2 83	—	—	—	1 7	—	4 100
TOTAL ..	2 9	3 71	5*100	7 93	22*440	17 428	2 34	1 4	2 16	2 17	3 26	66 1238

NOTE.—E.=Engine. H.P.=Horse-power. * Horse-power estimated.
† Used to pump water from the Thames, but for the use of a distillery.

TABLE

ENGINES ERECTED IN ENGLAND BY BOULTON & WATT

County.	Cotton Mills	Wool & Worsted Mills	Rope & Flax Mills	Bleachery	Calico Printing	Dyehouses	Canals	Collieries	Water Works
	E. H.P.	E. H.P.	E. H.P.	E. H.P.	E. H.P.	E. H.P.	E. H.P.	E. H.P.	E. H.P.
Cheshire ..	6 81	—	—	—	—	—	—	—	—
Cumberland ..	—	—	—	—	—	—	—	3 39	—
Derbyshire ..	1 8	—	—	—	—	—	—	1 4	—
Durham	3 76	—	1 16	—	—	—	—	—	—
Essex	—	—	—	—	—	—	—	—	—
Gloucester ..	—	—	—	—	—	—	2 56	—	—
Kent	—	—	—	—	—	—	—	—	—
Lancashire ..	13 217	—	—	1 12	—	—	3 14	—	—
Leicestershire ..	2 22	—	—	—	—	—	—	—	—
Lincolnshire ..	—	—	—	—	—	—	—	—	—
Middlesex ..	4 36	—	—	—	—	—	—	—	3 91
Northumberland	—	—	—	—	—	—	—	2 36	—
Nottinghamshire	12 158	—	—	—	—	—	—	—	—
Oxfordshire ..	—	—	—	—	—	—	—	—	—
Shropshire ..	—	—	1 20	—	—	—	—	11 84	—
Staffordshire ..	1 26	—	—	—	—	—	6 82	3 46	—
Surrey	—	—	—	—	1 4	2 32	—	—	—
Warwickshire ..	—	—	—	—	—	—	—	2 11	—
Yorkshire ..	5 112	2 60	1 28	—	—	—	—	—	—
Totals ..	47 736	2 60	3 64	1 12	1 4	2 32	11 152	22 220	3 91

II

between December 31, 1785, and December 31, 1795.

Corn Mills	Foundries and Forges	Paper Mill	Salt and Lead Mines and Works	Glass and Pottery	Distilleries	Breweries	Tannery	Oil, Colour, Drug, Tobacco, Sugar, Starch, White Lead	Totals
E. H.P.	E. H.P.	E. H.P.	E. H.P.	E. H.P.	E. H.P.	E. H.P.	E. H.P.	E. H.P.	E. H.P.
—	—	—	1 10	—	—	—	—	—	7 91
—	—	—	—	—	—	—	—	—	3 39
1 8	—	—	—	—	—	—	—	—	3 20
—	—	—	—	—	—	—	—	—	4 92
—	—	—	—	—	—	—	—	1 4	1 4
—	—	—	1 10	—	1 18	—	—	—	4 84
—	—	—	—	—	—	1 3	—	—	1 3
—	—	—	—	1 14	—	1 4	—	1 10	20 271
—	—	—	—	—	—	—	—	—	2 22
—	—	—	—	—	—	—	—	1 4	1 4
1 20	—	—	1 8	—	3 82	6 64	1 6	6 62	25 369
—	—	—	—	—	—	—	—	1 16	3 52
—	—	—	—	—	—	1 4	—	1 8	14 170
2 16	—	—	—	—	—	—	—	—	2 16
—	2 16	—	—	—	—	—	—	—	14 120
—	5 86	—	—	1 8	—	—	—	—	16 248
1 10	1 36	—	—	—	1 14	1 10	—	2 28	9 134
—	1 12	—	—	—	—	—	—	—	3 23
1 14	—	1 10	—	—	—	1 6	—	1 17	12 247
6 68	9 150	1 10	3 28	2 22	5 114	11 91	1 6	14 149	144 2009

TABLE

ENGINES ERECTED IN ENGLAND BY BOULTON & WATT

County	Cotton Mills	Wool and Worsted Mills	Rope and Flax Mills	Bleachery	Calenderers and Glaziers	Canals	Colliery
	E. H.P.	E. H.P.	E. H.P.	E. H.P.	E. H.P.	E. H.P.	E. H.P.
Cheshire	3 52	—	—	—	—	—	—
Durham	—	—	—	—	—	—	—
Gloucestershire ..	—	1 12	—	—	—	1 5	—
Lancashire.. ..	29 523	2 40	—	2 34	—	—	—
Leicestershire ..	—	—	—	—	—	—	—
Middlesex	—	—	—	—	1 12	1 15	—
Northamptonshire	1 12	—	—	—	—	—	—
Northumberland ..	—	—	1 8	—	—	—	3 60
Nottinghamshire ..	1 30	—	—	—	—	—	—
Oxfordshire ..	—	—	—	—	—	1 13	—
Shropshire.. ..	—	—	—	—	—	—	—
Staffordshire ..	—	—	—	—	—	—	—
Surrey	—	—	—	—	—	—	—
Warwickshire ..	1 20	—	—	—	—	—	—
Wiltshire	—	—	—	—	—	1 5	—
Yorkshire	—	4 68	—	—	—	—	—
Kent	—	—	—	—	—	—	—
Totals.. ..	35 637	7 120	1 8	2 34	1 12	4 38	3 60

III

between December 31, 1795, and December 31, 1800.

Water Works	Corn Mill	Forge and Foundry	Lead Works	Glass and Pottery	Distillery	Brewery	Shot Mill	Colour Laboratory, White Lead, Oil Mills	Total
E. H.P.	E. H.P.	E. H.P.	E. H.P.	E. H.P.	E. H.P.	E. H.P.	E. H.P.	E. H.P.	E. H.P.
—	—	—	1 16	—	—	—	—	—	4 68
—	—	—	1 24	—	—	—	—	1 8	2 32
—	—	—	—	—	—	—	—	—	2 17
—	—	—	—	1 16	—	—	—	1 6	35 619
—	—	—	—	—	—	—	—	1 8	1 8
3 57	—	—	—	—	—	3 38	—	2 18	10 140
—	—	—	—	—	—	—	—	—	1 12
—	—	—	—	—	—	—	—	1 16	5 84
—	—	—	—	—	—	—	—	—	1 30
—	—	—	—	—	—	—	—	—	1 13
—	—	1 20	—	—	—	—	—	—	1 20
—	—	—	1 12	1 30	—	—	—	1 32	3 74
—	—	—	—	—	—	1 10	1 4	—	2 14
—	1 16	—	—	—	—	—	—	—	2 36
—	—	—	—	—	—	—	—	—	1 5
—	—	1 20	—	—	—	—	—	1 12	6 100
—	—	—	—	—	1 20	1 4	—	—	2 24
3 57	1 16	2 40	3 52	2 46	1 20	5 52	1 4	8 100	79 1296

TABLE

ENGINES ERECTED OUT OF ENGLAND

PLACE OF ERECTION	Cotton Mills	Flax Mills	Canals	Collieries	Corn Mills	Foundry & Forge
	E. H.P.	E. H.P.	E. H.P.	E. H.P.	E. H.P.	E. H.P.
WALES—						
Anglesey	—	—	—	—	—	—
Flint	—	—	—	—	—	1 49
Glamorgan ..	—	—	—	2 12	—	3 204
Monmouth ..	—	—	—	—	—	1 20
SCOTLAND—						
Argyll	—	—	1 8	—	—	—
Clackmannan ..	—	—	—	—	1 10	—
Edinburgh ..	—	—	—	1 10	—	—
Falkirk	—	—	—	—	1 20	—
Fife	1 12	—	—	—	—	—
Forfar	—	1 20	—	—	—	—
Haddington ..	—	—	—	—	—	—
Lanark	2 42	1 12	—	—	1 30	1 10
Perthshire ..	1 30	—	—	—	—	—
Renfrew	4 44	—	—	—	—	—
IRELAND	—	—	1 3	1 10	1 14	—
FRANCE	—	—	—	—	—	1 38
SPAIN	—	—	—	—	—	2 98
Total to 1785 ..	—	—	—	2 20	—	1 38
Total to 1795 ..	—	—	2 11	2 12	—	4 176
Total to 1800 ..	8 128	2 32	2 11	4 32	4 74	9 419

IV

BY BOULTON & WATT from 1775–1800.

Copper Mines	Distillers	Breweries	Glass Works	Water Works	Total to 1785	Total to 1795	Total to 1800	
E. H.P.	E. H.P.	E. H.P.	E. H.P.	E. H.P.	E. H.P.	E. H.P.	E. H.P.	E. H.P.
1 3	—	—	—	—	—	1 3	1 3	
—	—	—	—	—	—	—	1 49	
—	—	—	—	—	—	3 80	5 216	
—	—	—	—	—	—	—	1 20	
								8 288
—	—	—	—	—	—	1 8	1 8	
—	1 14	—	—	—	—	1 14	2 24	
—	1 32	—	1 16	—	1 10	—	3 58	
—	—	—	—	—	—	—	1 20	
—	—	—	—	—	—	—	1 12	
—	—	—	—	—	—	—	1 20	
—	1 14	—	—	—	—	1 14	1 14	
—	—	1 8	—	—	—	1 10	1 102	
—	—	—	—	—	—	—	1 30	
—	—	—	—	—	—	—	4 44	
								21 332
—	—	—	—	—	1 10	1 3	3 27	
—	—	—	—	1 85	2 123	—	2 123	
—	—	—	—	—	—	2 98	2 98	
								7 248
—	—	—	—	1 85	4 143			
1 3	2 28	—	—	—	—	11 230		
1 3	3 60	1 8	1 16	1 85	—	—		36 868

Table V

GEOGRAPHICAL DISTRIBUTION OF ENGINES ERECTED BY BOULTON & WATT in England 1775-1800.

County	1775-1785		1785-1795		1795-1800		Total	
	E.	H.P.	E.	H.P.	E.	H.P.	E.	H.P.
Cheshire ..	1	14	7	91	4	68	12	173
Cornwall ..	21	420	—	—	—	—	21	420
Cumberland ..	—		3	39	—	—	3	39
Derbyshire ..	1	20	3	20	—	—	4	40
Durham ..	—		4	92	2	32	6	124
Essex	1	5	1	4	—	—	2	9
Gloucester ..	—		4	84	2	17	6	101
Kent	—		1	3	2	24	3	27
Lancashire ..	—		20	271	35	619	55	890
Leicestershire..	—		2	22	1	8	3	30
Lincolnshire ..	—		1	4	—	—	1	4
Middlesex ..	6	97	25	369	10	140	41	606
Northants ..	—		—	—	1	12	1	12
Northumberland	1	20	3	52	5	84	9	156
Oxfordshire ..	—		2	16	1	13	3	29
Shropshire ..	10	301	14	120	1	20	25	441
Staffordshire ..	12	181	16	248	3	74	31	503
Surrey.. ..	5	41	9	134	2	14	16	189
Warwickshire..	1	20	3	23	2	36	6	79
Wiltshire ..	—		—		1	5	1	5
Worcestershire	1	10	—		—		1	110
Yorkshire ..	4	100	12	247	6	100	22	447
Totals ..	66	1238	144	2009	79	1296	289	4543

TABLE VI

INDUSTRIAL DISTRIBUTION OF ENGINES ERECTED BY BOULTON & WATT in England 1775-1800.

INDUSTRIES	1775-1785		1785-1795		1795-1800		TOTAL	
	E.	H.P.	E.	H.P.	E.	H.P.	E.	H.P.
Cotton Mills ..	2	9	47	736	35	637	84	1382
Wool and Worsted Mills ..	—		2	60	7	120	9	180
Rope and Flax Mills.. ..	—		3	64	1	8	4	72
Bleachery ..	—		1	12	2	34	3	46
Calico Printing	—		1	4	—		1	4
Dyehouses ..	—		2	32	—		2	32
Calenderers and Glaziers ..	—		—		1	12	1	12
Canals	3	71	11	152	4	38	18	261
Collieries ..	5	100	22	220	3	60	30	380
Water Works..	7	93	3	91	3	57	13	241
Corn Mills ..	2	34	6	68	1	16	9	118
Copper Mines..	22	440	—		—		22	440
Foundry and Forge ..	17	428	9	150	2	40	28	618
Breweries ..	1	4	11	91	5	52	17	147
Potteries and Glasssworks..	2	16	2	22	2	46	6	84
Rolling Mill ..	2	17	—		—		2	17
Paper Mill ..	—		1	10	—		1	10
Salt and Lead Mines & Works	—		3	28	3	52	6	80
Distilleries ..	—		5	114	1	20	6	134
Tannery ..	—		1	6	—		1	6
Shot Mill ..	—		—		1	—	1	—
Oil, Starch, Colour, Drug, Tobacco, Sugar, White Lead, Laboratory Mills.. ..	3	26	14	149	8	100	25	275
Totals ..	66	1238	144	2009	79	1296	289	4543

At the beginning of the nineteenth century, then, the use of steam-power in industry was neither universal nor extensive. The total number of engines in Great Britain and Ireland, in the year 1800, was 321, representing a total horse-power of 5,210. Nevertheless, the location and purpose of these 321 engines is of considerable importance. It is a curious fact that they are nearly all employed in comparatively new industries. The newest industry in the country, the cotton trade, used eighty-four engines of 1,382 horse-power. The wool trade that, up to 1731, had been protected by Parliament, used only nine engines of 180 horse-power. This was probably due to the fact that the organization of the woollen trade was only just developing out of the domestic into the factory system, and that wool was very liable to snap when spun and woven mechanically.[1] On the other hand, the cotton trade was a new thing, and had no great weight of domestic tradition behind it; it had not been localized in sheep-rearing districts for centuries, and its organization was much less stabilized. Rapid development was easy and power was largely applied.

If we look at the other industries that used steam-power in 1800, it becomes clear that, apart from mines, water-works, canals, and iron-works, the steam-engine was hardly used in industry.

The mines had to use the steam-engine in order to proceed at all, their only alternative being the constant sinking of new shafts in order to work at levels

[1] Knowles, *Industrial and Commercial Revolutions*, p. 50.

where drainage was not an all-important problem.

The water works and, in many cases, the canals could not exist without steam-power, for their very existence depended upon the regular raising of large quantities of water to high levels. Steam was the only power that made this possible.

The iron works also had a special reason for needing steam-power, the smelting of iron with coal had made an increased blast necessary. The iron-works were usually situated on the coal and iron seams, where coal was easily obtainable and cheap power from water was not often available. The power to drive the bellows for the increased blast was obviously best obtained from coal-driven steam-engines, and the success of John Wilkinson along such lines was a valuable advertisement and recommendation for the use of the steam-engine in iron-works.

As regards the distribution of the engines geographically, it is obvious that the bad state of the roads made it essential for cheap working that the engines should be situated on the coal-fields, or where coal could be easily transported by water, i.e. by canal or coast route. In fact, the only engines built off the coal-fields were those in Cornwall, where coals came by sea, but were always difficult to obtain,[1] and those which surrounded the metropolis itself.

[1] Boulton to Watt, October 17, 1782. Tew MSS.: "Yesterday . . . 100 Sail of Colliers were expected at Falmouth . . . but was extremely disappointed to see only 25 of them enter the Harbour, and all the rest sail forward to Plymouth. . . . There is not enough coals in the country to carry the mines through the winter."

Boulton to Watt, October 18, 1782. Tew MSS. Boulton

London, of course, had long possessed an adequate coal supply, though it was carefully controlled and regulated by a limited number of coal dealers, who owned the wharves and quays where the Newcastle Fleet unloaded.[1] Otherwise the steam-engines were built on the coal-fields. This was the end of many industries, which could easily have used increased power, but were unable to obtain it, owing to their situation away from the coal-fields.[2]

This helps to account for the gradual introduction of steam-power. The steam-engines were generally erected in new enterprises near the coal-fields, while the old centres of localized industry continued along traditional lines. Gradually competition added to the numbers of the power-driven works and decreased those of the older type, until the industries that needed power were almost all clustered

offers to pay 5s. per weigh in addition to the price to persuade colliers to bring coals to Cornwall. See also *Holt and Gregson, MSS.*, Liverpool Municipal Library, Vol. 10, pp. 259–263.

[1] "Coal crimps are sometimes Factors, selling ship loads of coals by commission; others are a sort of merchant buying up large quantities and disposing of them to the lesser wholesale dealers. . . . A person who makes any tolerable figure in this way deals for many thousands a year."—*A General Description of All Trades*, 1747. See also Knowles, *Industrial and Commercial Revolution*, p. 99, note 4. The difficulty of supplying distant places with coals increased in war-time, especially the coast-wise traffic, "owing to many Collier Ships having been engaged by merchants at a high premium to carry goods to Hamburg, etc." *The Farington Diary*, ed. Greig, Vol. I, p. 259, January 5, 1799.

[2] e.g. The woollen and cutlery industries of Essex; the woollen industry of Gloucestershire and Norfolk; the iron industry of the Weald and Hampshire at this date [1775–1800] are all declining.

round or on the coal-fields. All this happened before the days of the railway and rapid coal transport. The movement of industry is now rather away from the coal-fields than towards them ; a state of things that is the result of many influences, some social and some purely economic.

It is strange that the position of the steam-engine in its early years has been so neglected by economic historians ; even Mantoux, who claims to have seen the records of the firm of Boulton & Watt, makes several mistakes in his dates of the earliest application of steam to various trades.[1] Moreover, another historian says that as in 1800 there were only fifty-three steam-engines in Birmingham, Manchester, and Leeds, " the steam-engine only gradually supplanted water as a motive power." This, of course, proves nothing, as there is no comparison made between water and steam-power.[2]

At any rate, it is obvious that an adequate and

[1] He states that Wedgwood introduced steam in 1790 into his pottery ; whereas the dates of Wedgwood's engines are 1782, 1784, 1793, and 1800. While Toynbee, *Industrial Revolution*, gives 1788 as the date of the application of the steam-engine to blast furnaces. This should be 1776, by J. Wilkinson, at Broseley.

[2] Knowles, *Industrial and Commercial Revolution*, p. 73. In Manchester in 1820 there were sixty-six mills all steam driven. The cotton import was 151 million pounds in 1820, in 1800 it was only 55 million pounds. The general centre of the manufacture did not change during these years, therefore it is fair to say that Manchester had at most thirty cotton mills of all descriptions in 1800. At that date, according to the engine books, Manchester had thirty-two steam cotton mills and not twenty-two as stated by Mantoux and quoted by Knowles. While if the townships included in the 1820 estimate of sixty-six are included, the total in 1800 is thirty-eight. Baines, *History of the Cotton Manufacture*, pp.363–400.

accurate account of the position of steam-power in 1800 is very necessary to give precision to the economic history of that period.

The story of the early progress of steam-power in industry is easily epitomized. At first it was used as a matter of sheer necessity by the mines; then later it enabled new methods to be employed in smelting iron and working textile machinery of a new and powerful description: then lastly it replaced other types of power in the rest of the industrial field, wherever coals became cheap.

CHAPTER IX

Capital in 1800

(1) *Amount*

"It is impossible to estimate with precision the progress of national riches, as they arise from the aggregate savings of all the individuals in the State; but it is not difficult by many obvious circumstances to discern in which of any two periods of time it has been most rapid. If there have been extraordinary sums expended upon works of public utility; if harbours, bridges, high roads, and inland navigation have been improved and multiplied; if numerous buildings have suddenly arisen; if cultivation has extended over wastes; if shipping has increased in a manner more remarkable at one period than the other—no one can hesitate in deciding in which the national capital, and consequently the public power and prosperity, has most rapidly augmented. It will hardly be denied that all these signs of eminent felicity exist in the nation beyond all former example."[1]

[1] N. Vansittart, *Reflections, etc., London,* 1794, pp. 122–7. Boulton's son has some illuminating thoughts on the growth of capital in a MSS. pamphlet called *Thoughts Explanatory of the Pressure Experienced by the British Agriculturist and Manufacturer. By One of Both Vocations.* April, 1827. Tew MSS.

Such is the opinion of an understanding observer, in 1794. Moreover, it is a statement which is supported by an estimate, quoted by Sir Robert Giffen, which was made in 1800. The estimates, made on the eve of the eighteenth century, varied from 250 to 320 million pounds, while an estimate of 1740 gave the national capital as 480 million pounds.[1] All these estimates gave land an amount varying from slightly under to slightly over two-thirds of the total.[2]

Now, in 1800, we find a tremendous increase in the country's estimated capital, and a large alteration in the relative amount allotted to land, and to the rest of the fixed and floating capital of the country respectively.

The following is Giffen's summary of "*Observations on the Produce of the Income Tax*," by Rev. H. Beeke, B.D., 1800:

	Income Million £	Years' Purchase	Capital Million £
Lands	24	30	720
Tithes	2·5	30	75
Houses	11·5	18	200
Mines, Canals, Tolls, etc. ..	5	20	100
Farming Capital	17½	7	125
Home Trade	18	6½	120
Foreign Trade and Shipping	10	8	80
Foreign Possessions ..	4		
			1,420

[1] R. Giffen, *Growth of Capital*, 1889, p. 87.
[2] *Ib.*, pp. 74–80.

	Capital Million £
Waste Lands	30
Household Furniture	160
Plate, Jewels, etc.	50
Specie	40
	1,700
Shipping, Arsenals, etc.	15
Provincial and Municipal Buildings, etc.	25
	1,740

This rise is astonishing, and out of all proportion to the rise in population, nor can the increase be wholly due to the remarkable rise in prices, which commenced with 1780. There must have been a great increase during the century, not only in money values, but in things.

The change is most obvious when we compare the difference in the proportion of the total which represented the capitalized income of land. From being two-thirds of the whole, it has become less than half. This points to an obvious conclusion: there must have been either a rapid change in values with a decline in rents, or the amount of fixed capital in the country must have been rapidly increasing throughout the century. It is well known that the first of these things did not happen, in fact an increase of rents had begun in 1790 which continued until 1830.[1] Therefore we are

[1] Toynbee, *Industrial Revolution*, p. 117.

left with the alternative that during the eighteenth century a large increase in the total capital of the country took place. This increase, though partly due to the sinking of capital in land due to the development of scientific farming, was beyond measure mainly the result of a tremendous increase in fixed and floating capital, as a result of rapid industrial and commercial development, in which the industrial element largely predominated.

(2) *Steam-Power and Capital*

The fact that the most rapid increase took place in the latter half of the century, makes any evidence which throws light upon the development of fixed capital in industry of great importance. "Direct employment, net wages, steam-power, large scale industry,"[1] are the marks which point an industry as capitalistic in organization. At the end of the eighteenth century, steam-power meant large scale industry, and the two combined stood for the most advanced type of capitalism then in existence. Therefore, the use of the steam-engine (bringing with it the use of true machinery)[2] in any industry meant the presence of much capital in that industry, and the consequence was a large addition to the fixed capital of the country.

Mines were capitalist, at least those that employed steam-power were owned by large proprietors or

[1] C. R. Fay, *Life and Labour in the Nineteenth Century*, p. 226.

[2] K. Marx, *Capital*, p. 367. A machine according to Marx consists of three parts, the motor mechanism, the transmitting mechanism, and the working tool itself.

companies.[1] The Cornish copper mines were worked by a kind of joint-stock limited liability company.[2] The coal-mines, where they were so deep as to need engines for drainage, likewise were capitalist in organization, being in many cases the property of the local aristocracy, who owned the land under which the coal-mines were.[3] It is, however, probable that in Staffordshire and other places where the coal cropped out on the surface, small capitalists were working shallow shafts, and the organization of the "butty" system was growing up. The capitalist had taken possession not only of the textiles, but was also organizing some of the allied trades, for by 1800, steam-engines were at work in bleaching, calico printing, dyeing, and calendering. Thus, in the textiles, specialization was going on rapidly, operation after operation was being capitalized and organized as a separate industry. In the cotton trade many companies had grown up. In Manchester there were the Salford Twist Company (first engine, 1791) and the Chorlton Twist Company (first engine, 1794), while in Paisley there was the Underwood Spinning Company (first engine,

[1] Boulton & Watt to Chapman, of Newcastle, February 22, 1777. Tangye MSS. Boulton & Watt to Colville, of Torrybourn, Scotland. Tangye MSS. Boulton & Watt to G. Meason, Edinburgh, April 24, 1777. Tangye MSS.

[2] *Vide supra*, p. 119.

[3] Boulton to Watt, September 17, 1783. In Ireland £11,000 was spent by one Coleclough in establishing a colliery before any sales were made. Tangye MSS. Fay, *op. cit.*, p. 224. Though it is probable that in the Midlands many of the mines were small works needing little capital, worked by the small owners, who were afterwards to be exploited by the "butty" system.

1798). These were, of course, only convenient names for partnerships, in which a large number of people participated, but, nevertheless, they show an increase in the numbers of the investor class, for it is obvious that not more than one or two men were required to manage a cotton mill. However, the majority of the cotton mills were the property of one or two capable men.[1] The amount of capital invested in public works at this period must have increased very rapidly. In canals alone much capital was very quickly sunk. Watt estimated that the cost of a canal to cover the three or four miles from Monkland to Glasgow would be £10,000,[2] while the cost of the Bridgewater Canal, from Worsley to Runcorn via Manchester, was £220,000.[3] Moreover, after the first canals had been successful, an immense number of Navigation Acts received the sanction of the legislature, and canal works were in progress all over the country. In the Gazette of August 18, 1792, eighteen new canals were announced, and the shares of others were already at large premiums.[4]

There was a period of speculation, and more canals were built than were immediately required, but eventually all were opened up for traffic, and though individuals lost, the country was developed and the community benefited immensely. In the

[1] e.g. Drinkwater; Peel; Ainsworth & Co.; McConnell & Kennedy; Sir Rd. Arkwright, etc.

[2] Watt to Small, December 12, 1769. Tew MSS.

[3] Smiles, *Brindley*, p. 225.

[4] Grand Trunk, £350; Birmingham and Fazeley, £1,170; Coventry, £350; Leicester, £155. Smiles, *Brindley*, p. 296.

four years ending 1794, eighty-one Canal and Navigation Acts were obtained, authorizing a total expenditure of £5,300,000.

A curious point in connexion with the early subscriptions of capital for canals, before they became a speculation on 'Change, was that they were projected as necessities, and not from any idea of profit. The Duke of Bridgewater built his canal to convey his coals to Manchester and Liverpool, and the money to build the canal came mainly from the coal-mines themselves. Similarly with the Birmingham Navigation, which was inspired by Boulton and other manufacturers, who needed a method of obtaining fuel,[1] while the Grand Trunk was Josiah Wedgwood's conception, in order to convey his pottery unbroken to London.[2] Again, in spite of the speculation, the canals not only paid back their projectors in increased transport facilities, but also made them a handsome money profit.[3]

The same story is true of the water-works, except that the profits came in more slowly and speculation touched them less easily.[4] Of the other industries

[1] Boulton to Wedgwood, July 10, 1767. Boulton subscribed £1,000. Tew MSS.

[2] *The Present State of Birmingham*, 1789, p. 21.

[3] Boulton to R. Small, August 28th, 1781. Tew MSS. "Navigation shares for the last two half-years :

6 months at £9 per share	£63 0 0
6 months at £10 10s. per share ..	73 10 0
	£120 10 0

The present price of shares is 400 guineas."

[4] It is worth noting that the water-works which drew from the Thames gradually failed, while those which drew their supplies from more distant places came to the front.

the corn mills, breweries, and distilleries had been gradually increasing in scale during the century, and it is easily understandable that some of them should have sufficient capital to employ steam-power. The position of the small capitalist or master in these three trades was, as yet, fairly secure, in fact windmills were still being erected all over the country for several decades of the nineteenth century.

The breweries were becoming vast undertakings, and a movement seems to have been growing to divide the great bulk of the production between home brewing and "the great brewers who have large fortunes." "The small publicans, which the legislature and police seem apparently equally anxious to diminish,"[1] are beginning to feel the effects of large scale enterprise and social reform. The big capitalist brewers were already in existence before the introduction of the steam-engine, but its introduction, by Whitbread and others, about 1790, greatly accelerated their increase in output.[2]

The number of breweries that were of any impor-

[1] S. Child, *A Practical Treatise on Brewing*, p. 23.

[2] Brewers' returns in 1760 :

Calvert & Seward	..	74, 704 barrels
Whitbread	.. ..	60,508 ,,
Truman ..	.. ..	60,140 ,,
Sir W. Calvert	.. ..	52,785 ,,
Gifford ..	.. ..	48,413 ,,
Lady Parsons	.. ..	34,098 ,,
Thrale ..	.. ..	30,740 ,,
Huck ..	.. ..	28,615 ,,

A. Barnard, *Noted Breweries of Great Britain and Ireland*, Vol. I, p. 209.

tance seem to have been considerably reduced by the year 1796, for according to the statistics of the period, there were only twelve noteworthy breweries at that date. Whitbread heads the list with an output of 202,000 barrels, more than triple his output of thirty-six years before.[1]

The iron trade had likewise developed gradually into a capitalist enterprise, the rise of Wilkinson is an epitome of it. However, it was in the iron industry that many of the large increases in fixed capital took place. The machinery for boring, cutting, rolling, and splitting was all being rapidly introduced; accuracy was replacing roughness, and making all advances in execution cumulative.[2] Among the other industries of the country, steam-power had little direct influence; one tannery used an engine of six horse-power, one shot mill an engine of four horse-power, and so on. In fact, apart from the trades we have already discussed, there were only about thirty engines, representing a total of less than 400 horse-power, used in the country in 1800. However, steam-power had an indirect effect on many trades, and even on agriculture, by its influence on the iron and steel trades, the textiles and transport.

The capitalist growth of the century can be roughly and vaguely divided into three types.

[1] A. Barnard, *op. cit.*, Vol. II, p. 201.

[2] Boulton to Watt, January 9, 1782. Wilkinson's improvements in boring all meant improved accuracy in making the next machine. Bolton suggested that "it would be worth while to make a machine for dividing and cutting the tooth in good form out of sectors." Tew MSS.

The first became capitalist by gradual growth and enlargement, like the corn-mills, forges, and potteries, and had little need to rely on credit organization for their means of expansion. Secondly, there were the canals and water-works, and sometimes the mines, which, owing to the long waiting for returns, were specially suited to joint-stock enterprise, and were floated as ordinary companies. Thirdly, there were the new inventions which needed capital to float them, and which had recourse to the ordinary credit agencies and founded their enterprises on the capital collected and distributed by the banks.

Under this third heading there are also included old industries set up in new surroundings, and, after the establishment of capitalism in a trade, most new works. It is obvious that, in the generality of cases, new-comers to an industry must employ the newest methods and the most modern organization, in order to neutralize the advantage that the existing firms owe to their connexion and long established relations with markets both for raw materials and the finished product.

(3) *The Capitalist Class*

In 1800 there was a definite capitalist class, which had evolved during the preceding centuries. It had been recruited in various ways and from various classes. Partly it was composed of men who were in the direct line of descent from the master and craftsmen of the gilds, who had reached

their present position by the gradual separation of functions and the gradual evolution of the "subordinate" classes of foreman, craftsman, salesman, and so on. Partly, it was composed of land-owning families, who had special opportunity for manufacture, e.g. the mine-owners.[1] Another section of the capitalist class, and one whose numbers had been swelled rapidly since the growth of the national debt and joint-stock companies, was the ordinary investor. The members of this capitalist class (which had been created, at first, slowly by evolution, and during the eighteenth century, had grown rapidly larger by unexpected additions) though all nominally in the same financial position, did not all exercise the same functions.

The investor, for instance, was almost in the position of our modern shareholder, except that he was more directly in touch with the business, and in many cases actually capable of conducting it himself. The separation between the two functions of supplying the capital and managing the business, even in joint-stock companies, was not yet complete.[2] However, the great industrial leaders, Boulton,

[1] Boulton to Watt, February 11, 1783. Lord Waldegrave owned Radstock Colliery and pirated a Boulton & Watt engine. Tangye MSS. In an agreement in August, 1777, with Messrs. Ronald Crawford & Co., of Wanlockhead Colliery, the partners are stated to be the "Countess of Dumfries, Sir Peter Crawford, and Gilbert Meason, Esq., of Edinburgh." The last of these seems to have been the general manager of the mine. Tangye MSS.

[2] Boulton was invited to become manager of a joint-stock company for buying copper. Scott, *op. cit.*, *passim* has full details of the type of investor to 1720.

Wedgwood, Wilkinson, Crawshay, and Reynolds, did not belong to this investing class, who had, in many cases, made their money in one or other of the professions. Among the first investors in the Birmingham Navigation to the extent of £700, was a Doctor of Divinity ;[1] a Doctor and several Barristers were engaged as adventurers in the Cornish mines,[2] and three Professors of Law were members of the Shadwell Water-Works Committee.[3]

Nevertheless, some of the largest capitalists still belonged to that merchant class which had early specialized in the business of foreign trade,[4] and which was beginning to confine itself to investment, banking, and insurance ; and when they completed their careers in the city, they bought land and settled down in the country.[5]

The captains of industry were still exercising more than one function. The business of foreman, of merchant for raw material, and of shopkeeper for finished product, was almost invariably exercised by one man. The duties and position of the small master had not completely disappeared, and the

[1] Boulton to R. Small, August 28, 1781. Tew MSS.

[2] Boulton to Capper, November 11, 1782. Tew MSS.

[3] Boulton to Watt, May 22, 1777. Tangye MSS.

[4] Boulton to Watt, April 19, 1783. " . . . Mr. Pennant, who is a very amiable man, with ten or twelve thousand pounds a year, has the largest estate in Jamaica ; there was also Mr. Gale and Mr. Beeston Long, who have some very large sugar plantations there, who wish to see steam answer in lieu of horses."

[5] The effect of these Enclosure Acts which took place during the Napoleonic War was to enable self-made capitalists to obtain land.

paternal element was to be reckoned with in business organization.[1] However, the payment of cash, which was to cover all the obligations of the employer who employed, was rapidly becoming customary, " and payment for labour, conditions of housing, help in bad times, education, all these were now commuted in the payment of a weekly wage."[2]

Moreover, the rise of the journeyman to power as a master and capitalist, instead of being the rule as under the gilds, had become the exception as the result of a harsher competition. In consequence of this, the separation of the classes of employer and employed became more rigid—they were further apart, though it was still comparatively easy for a lucky or intelligent man to cross the gap.

The generation of capitalists that introduced steam-power into their works, and saw the real beginning of modern industry, were foreman employers, and lived near their work ; it was the next generation that moved away from their works into pleasanter surroundings.

[1] Ruskin, *Unto this Last*, p. 35 (1888 Ed.).
[2] M. Hovell, *The Chartist Movement*, p. 29.

CHAPTER X

Labour in 1800

The story of labour, in the eighteenth century, is the story of specialization and the division of labour. It is also the story of the development of intelligence and accuracy, at the expense of the artistic and beautiful.

The question of the origin of the wage-earning classes is bound up with the question of specialization. At the beginning of the century, England was mainly an agricultural country, and land was widely distributed among the population, even in the manufacturing districts. As the century went on, this altered; enclosures[1] and increasing trade forced the small farmer-craftsman to specialize either in industry or agriculture, while the consequent increase in the size and decrease in the number

[1] Hammond, *Village Labourer*, p. 17.

Years	Common and Field Waste Enclosure Acts	Acreage	Waste Acts	Only Acreage
1700–1760	152	237,845	56	75,518
1760–1801	1,479	2,428,721	521	752,150
Total	1,631	2,666,566	577	826,668

of farms set free a large amount of labour that was absorbed into industry.[1]

Moreover, the century saw a large and unexpected increase in the population. This was due to a variety of causes. The food supply, at all times a limiting factor, had rapidly increased as a result of the enclosure movement, scientific farming,[2] and improved transport. While the absence of plagues and the improvement in sanitation reduced the death-rate considerably. Moreover, the improvement in transport and increased movement of people about the country levelled up sex inequalities, and was a further factor in the increase, while the obsolescence of apprenticeship, and the great demand for labour, made marriage easier and earlier.

Many changes took place in the social and economic life of the working classes between 1700 and 1820, which re-acted on the growth of population, but the effects of many of them are at present almost impossible to trace or difficult to estimate.[3]

Thus there was an easily increased supply of labour freed or freeing itself from the ties of cultivation ready for the new industry.[4] Moreover,

[1] Cunningham, *Growth of Industry and Commerce*, Vol. II, pp. 555–6. Toynbee, *Industrial Revolution*, pp. 68–9.

[2] The statistics of cattle sold at Smithfield prove this :

Av. Weight :	Beeves	Calves	Sheep	Lambs
1710 ..	.. 370 lb.	.. 50 lb.	.. 28 lb.	.. 18 lb.
1795 ..	.. 800 lb.	.. 143 lb.	.. 80 lb.	.. 50 lb.

Report of Committee on the High Price of Corn, 1795, p. 204 n.

[3] e.g. Immorality in factories ; employment of women meant shorter lactation periods, and so on.

[4] Toynbee, *op. cit.*, p. 8. The increase in population was from (about) 5,134,516 in 1700, to 6,039,684 in 1750, while in 1801 the first census return gives the population as 9,187,176.

the quality of the labour was physically good. Industry could draw "upon a reservoir of hard physique; nourished by open-air life, and winnowed by all the forces of natural selection."[1]

The new labour, in the beginning, was healthy and robust, though, perhaps, not remarkable for its intelligence and skill. Among the papers of Boulton & Watt, we find constant complaints of the lack of skilful, or even sober workmen. The decay of apprenticeship that had already set in at the beginning of the century was by the end of it far advanced. Moreover, the expansion of industry was, in many cases, too rapid for the supply of apprentices to adjust itself over a seven year period, and on the other hand, the violent and often unexpected enclosures forced large numbers into the labour market at very short notice.[2] The consequence of this was that trained and skilled labour in the new trades was very scarce. The textiles were in the best position in this respect, for many of the operations were known from the domestic industry, while the remainder were easily learnt and very mechanical.

It was in the non-textile trades that the difficulty was most felt. The potteries and engineering works had the greatest difficulty in obtaining intelligent men; while in an age when drink was

[1] *Observer*, leading article, August 20, 1922.

[2] Hammond, *The Village Labourer*, pp. 17, 19. Three million acres were enclosed in the last forty years of the century by Act of Parliament alone. Dr. Slater (*Sociological Review*, January, 1912) estimates the acres enclosed without an Act in the eighteenth century as 8,000,000.

one of the commonest methods of enjoyment, sobriety was almost unheard of.

Even in the potteries, where men had been trained in the old-fashioned methods, they were almost useless in the new industry, as developed by Wedgwood. He had to train practically every man whom he employed.[1] At his first considerable increase (1761) in the number of his workmen, he adopted the principle of specialization and division of labour. Hitherto it had been the custom for the "journeymen potters to pass from one kind of labour to another, just as impulse or convenience prompted, and this without reference to either the necessities of the moment or their master's interest."[2] Wedgwood saw the evils of the old system, the slovenly habits it begot in the workmen, and the loss of time and efficiency in production. He thought it easier to teach a workman one operation than a score, and the result proved the success of his system.

In the engineering trade the matter was not quite so simple. The theory of steam-power was, in 1774, far in advance of the constructional power of the workmen. Smeaton's criticism of Watt's engine, when he first heard of it, was that neither the tools nor the workmen existed that could manufacture so complex a machine with sufficient precision.[3] Fortunately, the question of tools was

[1] Meteyard, *Josiah Wedgwood*, Vol. I, p. 255.

[2] *Ib.*, p. 260.

[3] Boulton to Watt, April 23, 1776. Smeaton called it "a pretty engine." Tew MSS.

overcome to a sufficient extent by Wilkinson's invention of an improved boring machine.

The labour difficulty was more important. In the first place, there was a scarcity of ordinary smiths capable of any sort of iron-work. At least there was a scarcity of smiths who were free to be collected in a large works, they were mostly village blacksmiths. However, the trade was specialized, as its organized state in London in 1745 proves.[1]

Boulton & Watt decided that it would be impossible to obtain smiths to do any of the parts of their engines at Soho, except those peculiar to their own patent.[2] Even this small amount of work could with difficulty be completed.[3] This was a scarcity which continued for many years, not only in Birmingham, but in Cornwall, where engine erecting had first become a trade. In 1780 Watt writes to Boulton, that " the Smith's work at Wh. Virgin, including Boylers, will require 40 pair of Smiths, which are not to be found out of employ in all this country ; for in all the mines where we are concerned I find a scarcity of these animals."[4]

This was not even the most serious difficulty. In a period of mechanical construction, when the erection of a steam-engine was a matter of humour-

[1] *General Description of All Trades*, 1747. There were then twelve different kinds of smiths in London.

[2] Watt to Jonathan Hornblower (senior), December 15, 1776. Tangye MSS.

[3] Watt to Chapman, November 17, 1777. " We were not able to find a sufficient number of good workmen to execute our part of them quick enough." Tangye MSS.

[4] Watt to Boulton, October 11, 1780. Tangye MSS.

ing and adjustment, and often a long period was spent by the engineer in coaxing it to work, there was a shortage of capable "engineers."[1] Watt, writing to Smeaton, in 1778, says, "We wish we could join you in saying that we can easily find operative engineers, who can put engines together according to plan as clockmakers do clocks; we have yet found exceeding few of them—partly owing to the inaccuracy with which they have been used to proceed, and partly to their prejudices against anything new."[2] Nor was this conservatism confined to the engineering trade, but was to be found in many other places, even where the innovation did not affect the workman himself.[3] This scarcity

[1] W. Fairbairn, *Lectures on the Rise of Engineering:* "At the commencement of 1750 the title engineer was unknown in the vocabulary of science." Moreover the word does not occur in the title of any book or treatise before 1800 so far as I have been able to discover. Watt ascribes the first use of the word to Smeaton. "Our present magistracy who have employed me in Engineering (as Mr. Smeaton terms it)." Watt to Small, December 12, 1769. Tew MSS.

[2] Watt to Smeaton, April 4, 1778. Tangye MSS.

[3] An instance of this was the turn-cock at the Shadwell Water Works. Boulton to Watt, September 25, 1778. "I then went to Ragfair and Saltpeter Bank to see how the water came, it being the highest part of the high service, but not one drop appeared. My suspicions then turned upon Tom the Turn-cock, who had repeatedly told the Gentlemen that he was sure *that* engine would never serve his high services, but as we had brought with us another man who had no liking for Tom and knew the cocks as well as he did, he therefore enabled us to detect Tom and unfold all the history. For Tom had turned all the water into other streets, although he swore he had not. We turned and shut those cocks, and then the water came with more vigour into all the houses of the higher service than ever they had seen it do in their lives." Tangye MSS.

of operative engineers continued even after the firm had been producing engines for ten years, for, in 1785, Boulton, while lamenting the decrease in orders, says, that " as it happens at present, we have at least three engineers too few here, there being eight engines all to be done in two or three months, and only three engineers."[1]

The scarcity of good men also applied to draughtsmen and clerks. For many years Watt did all the drawings for the engines himself, a duty which, combined with his ill health, often made delays in erection inevitable.[2]

These difficulties were gradually overcome. William Murdock, the inventor of gas lighting, came from Scotland, and was a valuable help to the firm. Other millwrights were engaged from Scotland, whence a constant supply of skilled labour came, owing to lack of native employment, until Scotland herself began to develop rapidly.[3] The difficulty in obtaining suitable clerks was also a limitation that eighteenth-century industry had to overcome. Usually the only man who understood both the clerical work and the business itself in a firm was the owner of it, thus demonstrating the fact that the capitalist in industry still combined

[1] Watt to Boulton, August 27, 1785. Tew MSS.

[2] Watt to R. Reynolds, December 31, 1777: " I am now engaged in making a set of drawings for an engine, which will employ me about six days." Tangye MSS.

[3] Boulton to Mackell, Engineer, Glasgow, February 10, 1777. Tangye MSS. Watt to Boulton, April 2, 1781: " The young Millwright is come from Scotland." Tangye MSS.

the functions of employer-foreman and, to some extent, that of merchant. In 1780 the engine firm were intending to engage a clerk, his wages were to be £70 to £75 per annum, and he was to take charge of the clerical side of the engine business. Hitherto the work had been shared between Mr. Pearson (cashier of the hardware business) and Henry Playfair, a practical engineer, and both were unsuitable.[1] Moreover, after the engines had been erected and engine-men were appointed to watch them, the scarcity of suitable labour was still a trial to the engine owners. Here dullness, though still a handicap, was not so damaging as the drunken habits of the engine-men.[2] Many times the engines were damaged by the inattention of a drunken workman.[3] Nor were the complaints confined to the engine business, Boulton had found it in his own works, and the dirtiness of the workmen in the Albion Mill was, for a time, a serious matter. However, men learnt quickly, and soon improved in cleanliness and technical skill, the only point

[1] Watt to Boulton, September 20, 1780: "Mr. Pearson does not understand our business and Playfair does not understand book-keeping nor method." Tew MSS.

[2] "These two fellows say their Masters seem to believe that it requires the learning and knowledge of a university man to keep an engine in order." Boulton to Watt, September 1, 1778. Tangye MSS. "Get some sober man to attend the engine, some man of common gumsion, though not a professed engine-man." Watt to Henderson (undated; probably June 28, 1779). Tangye MSS.

[3] Boulton to Watt, December 17, 1778: "The want of proper men to work our engines hath brought on a loss of money and reputation." Tangye MSS.

on which no improvement was visible was the drunkenness.[1]

Hands were also scarce in the Cornish mines themselves[2] and in the hardware trade.[3] The truth of the matter was that skilled labour was scarce and unskilled labour plentiful. The textiles and the canals absorbed much of the unskilled labour, just as the roads and railways absorbed the second influx of unemployed in the middle of the next century.[4] This scarcity of skilled men made it desirable that agreements should be made between employers and the men they desired to keep. Efforts were also made by other employers to induce men to desert to their service by offers of higher wages. These offers were made both by Englishmen and foreigners, and were dealt with in a peremptory fashion by the law.[5] Nor was this the only

[1] Boulton to Watt, October 18, 1779. Smeaton went to see the engine at Bow, and gave the engine man some money; he got drunk and let the engine run wild, with disastrous results. Jos. Harrison, the firm's best engineer, was untrustworthy in this respect. A Capt. Dick Williams invented a cure for swearing. "I wish Capt. Dick could cure drunkenness—it would be a more valuable receipt than that for swearing." Tangye MSS.

[2] Boulton to Watt, September 25, 1780. Tangye MSS.

[3] Watt to Boulton, September 12, 1780. Tew MSS.

[4] Fay, *op. cit.*, pp. 104–5.

[5] Aris's *Birmingham Gazette*, June 22, 1778: "Last week one Homer, formerly an inhabitant of this town, was convicted in London before Lord Mansfield in the penalty of £100 and sentenced to three months' imprisonment for endeavouring to entice artificers from this Kingdom to France." This was a nuisance to which Boulton & Watt were particularly open. In December, 1799, Wm. Harrison laid information to the magistrate that he had been offered more wages if he would go and work for Messrs. Fonton, Murray & Wood, of Leeds. Deposition of Wm. Harrison, December, 1799. Tangye MSS.

difficulty in connexion with the supply of labour: the country was at war during a large portion of the last half of the eighteenth century, and the Government frequently interfered to enlist men both in the army and navy. In July, 1781, Watt writes from Cornwall that " Our men are all obliged to go to-day to Kelstone to be drafted for the Militia, though they have not been three weeks in the County. Capt. Paul and I had sent a petition, and I have caused them to enter a club with the rest of the Parish, as a substitute here costs £20."[1] Their men travelling about the country, and even across the sea, to erect engines, were peculiarly liable to be seized by the press gang, and, in many cases, had difficulty in escaping.[2] Watt himself in his youth had, while in London, been in danger. James Law, on his arrival in Cornwall, wrote to Playfair to say that he had been stopped and examined by the press gang at Okehampton, and warned him to take care of any young hands he may have to send down.[3]

The employers of labour, in the eighteenth century, were thus not exempt from cares, nor were strikes unknown. In 1779, in the Staffordshire coal-mines, " a passion of mutiny and rebellion seized all the colliers, they being determined to

[1] Watt to Boulton, July 7, 1781. In 1757 the number of men to be raised in each county by its Lord Lieutenant had been fixed and the force organized on a definite basis. Tew MSS.

[2] When Wm. Harrison went to Cadiz he was given a note certifying " that he was no sea-man nor ever was at sea previous to this date." Tangye MSS.

[3] James Law to Wm. Playfair, June 10, 1781. Tangye MSS.

bring the ton weight down to its proper standard, and they thought the best time to do it was when the winter was so far begun that there remained not a single hundred weight of coal upon the Bank. . . . However, all is peace again at present, but not a solid one I think."[1] There had already been a strike of miners in the Newcastle coal-field, in 1764–5, when the trouble was that by an agreement among the pit-owners, no employer would employ another's men, thus binding the men to one pit, or as an alternative, leaving them to idleness.[2] This fear of the scarcity of labour seems constantly present in the minds of eighteenth-century employers, and it is rarely that the corresponding fear among the workers of unemployment comes to the surface. This is probably due to the ease with which poor relief was obtained, or to the fact that when unemployed the worker had, until the later years of the eighteenth century, his land and subordinate employment to keep him employed.

However, Boulton gradually collected round him a body of active workmen, skilful if somewhat untrustworthy. Many of his mechanics were Scotsmen,[3] and all were carefully trained. Soho, however, employed more than engineers; the hardware business still continued and, in 1791, seven hundred were employed there.[4] Boulton

[1] Boulton to Watt, October 17, 1779. Tangye MSS.

[2] Hammond, *The Skilled Labourer*, p. 13.

[3] On the completion of the Wheel Virgin engines Boulton gave a dinner to the mechanics; six Scotsmen and one Englishman sat down.

[4] Boswell, *Life of Johnson*, p. 488.

also contracted for coinages for our own and foreign Governments, and erected a mint, the whole employing large numbers of workmen. However, the paternal side of mastership had not wholly disappeared, for Boulton founded an Insurance Society for his employees, for sick benefit and funeral expenses. Payments varied from one halfpenny weekly from those receiving 2s. 6d. per week, to 4d. from those whose weekly wages were a pound. No members earning more than 20s. weekly were admitted.

Two points of interest were contained in the rules : Rule XII says that " any member who employs hands under him shall give an account of them to the Committee," while Rule XIII says that " when any member goes away, or is not employed for, or at this manufactory, he shall no longer receive any benefits from this society nor withdraw any money he has paid into it."[1]

The latter of these was, of course, merely copied from the ordinary insurance rules, but had the effect of retaining workmen at Soho, when otherwise they might have gone away, and perhaps throws a further light on the employers' fear of a shortage of labour.

The first rule, quoted above, is also interesting as it throws a light on the organization of Soho, which was, for a long time, a model factory to which many employers came for help. The large number of separate processes, and even different manufac-

[1] *Rules for Conducting the Insurance Society belonging to Soho Manufactory.* Tangye and Tew MSS.

tures proceeding at once, and the frequent absences of Boulton and Watt had made deputies essential. Boulton had, therefore, organized definitely from above a system of foremen for the purpose of discipline and maintaining the standard of work. The arrangement met with remarkable success, and Soho became an example of organization. Wedgwood came several times to Soho to see how the difficulties, occasioned by the irregular habits of the workpeople, had been overcome by his friend.

The contrast between the non-textile and the textile organization is clearly seen in the arrangements for keeping the works clean and healthy. Dirt and indecency, and so on, were subject to fines in both, but whereas in the cotton mills the fines filled the pocket of the employer, at Soho they went into the box of the Insurance Society.[1] Moreover, the point is made quite clear that "it is for the health, interest, and credit of the men as well as masters to keep this manufactory clean and decent."

All wages paid by Boulton & Watt were paid in money or house-rent. Wages of ordinary employees at Soho varied from boys at 2s. 6d. to about 20s. per week. The engine erectors were paid anything from 10s., or thereabouts, upwards. Cartwright was paid 15s. per week;[2] Mackell was offered 12s. 6d. per week,[3] whilst James

[1] Hammond, *Town Labourer*, p. 19–20. Rule xxiv Soho Insurance Society.

[2] Watt to Boulton, March 29, 1781. Tew MSS.

[3] Boulton to Mackell, February 10, 1777. Tangye MSS.

Murdock,[1] and his more famous brother, William,[2] were paid one and two guineas, respectively.

Soho was a combination of the old and new systems, in all that pertained to machinery, large scale production, its methods of obtaining credit, and organization of markets. Soho was as capitalist as any modern engineering undertaking, but in the functions of management and relationship between master and man, the separation of interests had not yet appeared, nor does Adam Smith's maxim, that the interests of employer and employed are in short periods antagonistic,[3] have much importance.

Wedgwood's position was similar to Boulton's, but in the mines and iron-works disturbances and strikes were becoming more and more frequent. Wilkinson, himself, had started to coin his own pence with which to pay his workmen, thus beginning a bad system of paying wages in other than the coin of the realm, a cause of friction during the next century.[4]

[1] *Memo relating to Jas. Murdock's Dismissal*, March 20, 1795. Tangye MSS.

[2] Watt to Boulton, September 28, 1780. Tew MSS.

[3] A. Smith, *Wealth of Nations*, p. 58.

[4] Boulton to Motteaux (a London Bank director), August 12, 1787. Tew MSS. "I will send you a few of Mr. Wilkinson's coin which he pays his workmen for pence. There is thirty-two of them to the pound, consequently he sells them at 2s. 8d. per pound, whereas the mint charge is 1s. 11d. per pound—a rare profit, and if Government doth not put a stop to ye trade every manufacturer in Birmingham will coin his own copper money."

CHAPTER XI

Industry and Foreign Trade

Boulton's business, even before he took up the steam-engine, had had direct connexions in many European countries. The addition of the steam-engine to his manufactures, for the time, concentrated his attention on England; but, at a time when markets for most commodities were restricted and local, there was, as there had always been, an international market for power.

Boulton's relations with France had always been successful and honourable. In 1768 Boulton was asked to send some counterfeit two sous pieces, but refused. "It is a trade that I have much exclaimed against since I saw a possibility of its being very prejudicial to our manufactory, and it may cause a more particular and more scrupulous prohibition of all such things as we are now enabled to introduce into France."[1]

However, Watt's engine was not the first English steam-engine to be exported to France. The first chapter in the long history in the quarrel about the exportation of machinery had already been written, about 1726. French authors manage to claim for Papin a large share in the invention of the steam-

[1] Boulton to Motteaux, January 15, 1768. Tew MSS.

engine,[1] and no doubt they are justified, but it is only recently that the existence in France of English steam-engines in the first quarter of the eighteenth century has been proved, and this by the exertion of a Frenchman. There existed, at Passy, and near Paris, and probably some other places, steam-engines erected by Englishmen, in the years 1726–7.[2]

The steam-engine was, then, not a success in France, Paris being contemptuous of the new invention.[3] However, about the time that Watt's engine first appeared to be successful, Paris was undertaking a new water-works scheme. Boulton,

[1] M. Arago, *Eloge sur Jas. Watt, passim.*

[2] "Privilege à Jean May Anglais d'etablir, construire, enseigner et mettre en pratique une nouvelle machine propre à élèver l'eau, dessécher les mines et marais dans tout le royaume." *Archives Nationales O, '71*, fo. 419, quoted by M. Lemonnier in a communication to the Commission du vieux Paris sitting in 1916, No. 9, p. 255. An engine had been erected by Meyer and May, Englishmen, at Passy; it burnt wood, but to what purpose it was put is as yet unknown. A Frenchman also erected a steam-engine in 1726, and both engines were examined by members of the Academie des Sciences: the results of which examinations are contained in the *Procès verbaux inédits de l'Academie des Sciences.* However, a Frenchman named Belidor in 1737–9 wrote a considerable book on *L'architecture Hydraulique*, which does not mention the engine at Passy, but gives one steam-engine only as then working in France, at a colliery at Fresnes. There is some curious discrepancy here, but until further evidence is secured, we can only say that shortly after 1727 Paris ceased to employ steam-engines, but that several engines existed outside Paris, and that those which still existed came from England. English writers are also ignorant of the existence of these early engines. Farey, *op. cit.*, refers only to the one at Fresnes.

[3] *Procès Verbal du Commission du vieux Paris*, 1916, p. 256.

hearing of this, wrote to Panchard, a banker in Paris, asking about the scheme, and desiring his assistance in obtaining a patent in France.[1] Wilkinson, who at the beginning worked very closely with the engine firm, was eager for the work to be obtained at any cost. Boulton & Watt would have preferred a grant of patent rights, but they comforted themselves with the fact that, though the French might find out the engine secrets, they could not maufacture one without Wilkinson's assistance.[2] Thus is shown the close dependence of the engineer upon the iron founder. Other inquiries from France about engines came to Birmingham,[3] but for a time, the engine firm stuck to the idea of a French patent. Early in 1779, however, M. Perier, of the Paris water-works scheme, came over to England to see Boulton & Watt and their engine. Boulton writes to Watt, "I was at Shadwell yesterday with Perier, the engine works well and hath shortened the men's day's work, as it only works from 6 to 6."[4] Perier was very well pleased with what he saw and arranged for a large engine to be supplied as soon as possible. In payment they were offered a choice between shares in the water-works company

[1] Boulton to Panchard, April 2, 1777. Tangye MSS.

[2] Watt to John Wilkinson, May 11, 1777. Tangye MSS.

[3] *Proposals by M. B. & J. W., of Birmingham, to Mr. Joseph Jary, Concessionaire du Roi pour les mines du nord près de Nantes*, April, 1778. Tangye MSS. Boulton to Magellan, May 2, 1778. Tangye MSS. "The Count de Heronville wants an engine upon the moeres near Dunkirk."

[4] Boulton to Watt, February 2, 1779. Tangye MSS.

and ready money; Boulton & Watt chose the latter because of the financial difficulties.[1]

The engine was of 85 horse-power, and there were difficulties over the transport, especially as England was at war with France at this time.[2] Thus passports had to be obtained, not only from England, but from France and America.[3] The boat chartered had difficulty in sailing, owing to an embargo on shipping, "which is very distressing to trade."[4] Eventually *The Mary* sailed, and having managed to elude the privateers of all fleets, reached France. The engine was forwarded to Paris and was set to work.

Two interesting accounts of the starting of the engine were given by two people, who were present, and subsequently visited Soho.

"Senor Carretto saw M. Perier and the engine just before it set to work, and in consequence thereof, he wrote an account of it to Turin, and said it did great honour to the French nation and to M. Perier in particular, who had told him that he had got the pipes and cylinders cast in England, but not a word of Watt."[5] A year later, Baron Reden and M. de Luc called at Soho, and the latter gave an account of the actual start of the engine in the

[1] Watt to Perier, April 6, 1779. Tangye MSS.

[2] France had declared war in February, 1778, and the action of the French fleet at Chesapeake Bay had cut off all hopes of relief being sent to the English forces in America, and had forced Cornwallis to surrender to the Americans in 1781.

[3] Watt to Wilkinson, July 6, 1779. Tangye MSS.

[4] Watt to Perier, August 12, 1779. Tangye MSS.

[5] Boulton to Watt, November 17, 1781. Tew MSS.

presence of the Royal Academy. " He says M. Perier did not pretend to the Academy that it was his own invention, but that the Academy knew it to be ours . . . which circumstance we did not know before, at least, I did not."[1] But M. de Luc was a friend of Perier !

In all this Wilkinson had heartily co-operated, and about this time he contracted for the supply of iron pipes (forty miles in length), necessary for conveying from the River Seine sufficient water for all Paris.[2] Wilkinson took shares in the Water-Works Company, which was a great success ; for after the end of the Napoleonic Wars, in 1815, Wm. Wilkinson collected £10,000 interest and principal for his shares, while Mr. Adam, as trustee of the estates of John Wilkinson, received a large sum, probably about half a million.[3]

British machinery and British capital were both being employed to develop French resources, at a time when the two countries were at war. More than that, John Wilkinson was of the opinion " that the French would soon be on an equal footing with England in the mercantile arts, if that country should turin out to be equally favoured and rich enough n minerals."[4] However, Wilkinson supplied Perier with a Boulton & Watt engine unknown to the engine firm, but the

[1] Watt to Boulton, October 29, 1782. Tew MSS.

[2] Randall, *The Wilkinsons*, p. 58.

[3] *Ib.*, p. 58.

[4] *Ib.*, p. 58.

quarrel was patched up, as both firms were interdependent.[1]

In 1786 Boulton and Watt went to Paris together, chiefly to see Boulton's son, but also on business. Various projects were suggested; new steam-engines, a hardware warehouse in Paris, coinage contracts, and the engagement of French artists.[2]

During the next year, Boulton's close relations with France continued. He wished a French artist, named Droz, to come to Soho, but the unsettled state of affairs prevented him from making up his mind. "I wish the ministry of France was once settled, and then I would offer Mr. Droz my advice what he should do, but it is in vain to say anything until we see whether Mr. De Calonne will keep his place or not." De Calonne, at this time, was struggling to obtain the approval of the Council of Notables for his financial policy, he failed and

[1] Boulton to Watt, February 11, 1783: "The engine now lying at Bersham I have just learnt is for Perier, who has sent a pass-port to convey it to St. Domingo, where it is to be erected. Put not your trust in founders." Tangye MSS.

[2] "In 1786 Mr. Boulton and I were in France, where he saw a very fine crown piece executed by Mr. P. Droz in a new manner. As to his mechanical abilities Droz joined that of being a good dye sinker, Mr. Boulton contracted with him to come over to England at a high salary and work at Soho, Mr. B. having then the prospect of an extensive copper coinage for the East India Company, as well as a probability of one from Government." Boulton to M. Pradaux, March 29, 1787. Tew MSS. In the same letter Boulton announces that he has "not yet come to any decision respecting the keeping of a warehouse in Paris; there are many things against it and many in favour of it, but I will very soon make up my mind." Also Watt, *Memorandum on Boulton*. Tew MSS.

was dismissed in the same year. Boulton, however, delayed a full opening up of trade with France; he says, "I fear the English are sending more goods to France than that market can consume, and thereby they will be obliged to sell many things for less than prime cost.

"When this first convulsion, occasioned by the commercial treaty, is over, and the trade found its proper level, I shall then think it more prudent to go into it. At present I am full of orders, and should lose many valuable customers if my invoices were to be seen in the Palais Royal."[1]

The commercial treaty between the two countries had been part of Calonne's policy, and had been concluded in September, 1786. The effect of this was to increase the French imports into England from 21,000,000 livres, before 1786, to 34,000,000 livres, in 1787. Nevertheless, the treaty caused much discontent in France, as the French manufacturers were often inferior to their English rivals in mechanical power and business organization. The French Revolution, until 1793, when England declared war on the Revolutionary Government, had no effect on trade relations with England. Boulton "executed a considerable quantity of beautiful coin for the Revolutionary Government of France, while we remained at peace with that country, which coin was afterwards suppressed by the arbitrary measures of a fresh set of rulers in that unhappy country, to the great loss of the

[1] Boulton to Pradaux, August 2, 1787. Tew MSS. *Cambridge Modern History*, Vol. viii, p. 99–100.

French contractors, who, nevertheless, paid Mr. Boulton honourably."[1]

He also executed medals for France after the outbreak of war, and at one time he sent twenty tons of medals to Messrs. Monneron, his Paris agents.[2] Boulton belonged to that section of the nation who, from the beginning, adhered to the principles of the French Revolution. Among his friends he numbered Priestley, Wilberforce, and Whitbread; while James Watt (junior) went to Paris with an address of congratulation to the Jacobin Club, in 1792.

However, it is noticeable that it was with difficulty that political treaties and ruptures could prevail upon the trading interest to conform to the decisions of governments. The economic motive was becoming stronger than the political one, at any rate, outside the ruling bodies of states.

Though France was the foreign country that was most closely connected with England at this date, other countries were interested in our engineering progress. In 1778 an inquiry was received from Holland,[3] and, in 1776, one from Silesia.[4] Germany,

[1] Watt, *Memorandum on Boulton.* Tew MSS.

[2] Amongst the medal subjects commemorative of the great event of the French Revolution were the following: The Emperor of Russia; assassination of the King of Sweden; restoration of King of Naples; final interview of the King of France; execution of King of France; execution of Queen of France; serment du Roi; Lafayette; J. J. Rousseau and Respublica Gallica.

[3] Boulton to J. P. H. van Liender, August 29, 1778. Tangye MSS.

[4] Watt to Fred Lewis Kaller, November 10, 1776. The terms offered are £5,000 for the delivery of an engine with instructions.

Prussia especially, was interested in steam-power, and following the inquiry, in 1776, a further inquiry from Prussia was made through M. Magellan, in 1778. Watt's answer was to demand an exclusive privilege for fourteen years at least, and to inquire whether the mines were "the immediate property of His Majesty's or farmed out."[1] After the peace of Hubertsburg (1763), when Prussia had finally established herself as one of the great powers, Frederick the Great set to work to restore his country, and managed so successfully that within seven years all traces of the war had nearly disappeared. Among his efforts were those for obtaining steam-power to clear his mines.[2] Men were sent over to England to attempt to discover the methods of erecting steam-engines and the secret of Watt's patent. Their unscrupulous methods are set forth in a document, written in 1786 by Boulton, which describes a series of attempts beginning in January, 1779,[3] when Master Assessor Buckling, Counsellor of Mines to his Prussian Majesty, unsuccessfully endeavoured to bribe Harrison and Cartwright,

[1] Watt to Magellan, March 24, 1778. Tangye MSS. Watt had previously investigated the Prussian engineering works. He says, "It gives me some consolation to see the great Leibnitz, the rival of Newton, bungling repeatedly, applying windmills to raise ore while water ran idle past him." Watt to Small, May 28, 1769. Tew MSS.

[2] Boulton to Watt, March 21, 1782: "The Baron (Reden) says there is not more than one mine at the Hartz that can want an engine they have been at an immense expense in bringing water over and through hills to turn water-wheels." Prussia acquired the Hartz Mountains in 1648. Tew MSS.

[3] Boulton to Watt, January 6, 1779. Tangye MSS.

who were erecting the engine at Chelsea, to betray their masters, and ended in 1786, when Baron Stein endeavoured to take notes about the engine at Barclay & Perkins brewery, and also to persuade Cartwright, who was again in London, to go abroad with him. In both of these attempts he failed, and Boulton sent him a complete account of the various machinations of Prussian spies, with the comment that the Baron's "conduct was not agreeable to Mr. Boulton's notions of Honour," and refused to see him.[1]

With the rest of Europe, nothing very important was done by the engine firm. The difficulty was usually over the patent grant, which Boulton & Watt insisted on. They had conversations with the Ambassadors of Sardinia and Venice, but nothing came of them,[2] and only four engines had been erected outside England, in 1800.[3]

Difficulties of payment often occurred, and after the commencement of the Revolutionary War, the exchanges rapidly got into a muddle. Boulton had a large business with Russia, and it was there that the matter was most serious.[4]

Boulton was so perturbed that, in 1793, he wrote to Lord Hawkesbury, Secretary for Foreign

[1] *Facts Relative to Baron Stein*, 1786 (circa). Tew MSS.

[2] Boulton to Watt, October 4, 1779. Tangye MSS.

[3] Two in France, and two at Cadiz, in Spain, *vide supra*, pp. 172-3.

[4] Watt had received favourable offers to go to Russia in 1775, but had refused. Boulton to Watt, February 25, 1775. "The balance of trade is always considerably in favour of Russia against England owing to our importing such large quantities of raw materials, iron, hemp, etc." *Farington Diary*, August 17, 1795.

Affairs, on the subject, "I need not point out to your Lordship the effect which the Anarchical state of France and the Country thereunto adjoining has upon our trade, by depriving us of our payments, and of more than quarter of our usual orders; to which add the serious distresses arising from the extraordinary rate of exchange between this and almost all the other commercial countries in Europe, which not only deprives us of our regular payments, but the orders also that are usually sent with them; and thereby puts it out of the power of the master manufacturer to employ one-half of the people he hath usually done. The calamities of War I bow to with patience, but these are exaggerated by the edicts and prohibitions of our friends and allies. The particular object of this letter is to mention that in consequence of a late edict, published by the Empress of Russia, I shall probably be plunged into great loss and difficulties, unless some means can be devised to mitigate them."[1]

The difficulty was met in a rough and ready manner; "In consideration of the low courses of exchange," Boulton allowed his debtors to pay only a part of the amount, sacrificing one-half of the difference between the amount at the old and the amount at the new rate of exchange.[2]

In connection with petitions and applications

[1] Boulton to Lord Hawkesbury, July 19, 1793. Tew MSS.

[2] Andrew Collins (Boulton's Russian traveller) to Boulton, August 19 or 30, 1793. Tew MSS. Boulton could obtain no support in this matter from Glasgow, whose only trade with Russia was the import of iron and deals. Lord G. Hamilton to Boulton, March 18, 1794. Tew MSS.

to the Government, the growth of Chambers of Commerce is important. A Chamber of Commerce is a combination of manufacturers, merchants, and others, in order to safeguard their interests and to develop and extend their business, and again shows the effect that increased uncertainty was having on manufactures. Boulton played a large part in the foundation of a Chamber of Commerce in Birmingham and was prominent in the deliberations of the London Chamber. The weight which his judgments carried in both these assemblies, shows that the prestige of his firm must have been very great, not only in home industry but also in foreign trade.

CHAPTER XII

Conclusion

In whatever direction we survey the industry and commerce of England during the last half of the eighteenth century, we see extension and development. The annual produce of its land and labour was most certainly greater in 1800 than in 1750, its industry more flourishing, and its trade more extensive.

This was due to a series of developments, which have become known as the Industrial Revolution. The central fact here discussed is the effect of one of these elements—the effect of steam-power, sold by an exceptionally highly organized business house. It is often asserted that there would have been an industrial revolution had the mechanical revolution never taken place ; and it may be true that industry, by simply following traditional lines, was developing a capitalist organization without assistance from science. In support of this, the enclosure movement and growth of large farms, the gradual increase in the size of the clothier capitalists, and the beginning of mills worked by water-power, are deduced. It may all be true, but it seems unimportant and rather futile to argue about what would have happened if something else had not done so.

The invention of the steam-engine as an industrial machine remains the central fact of eighteenth-century history, and not only is its direct influence on industry important, but the development of the firm which put it on the market is almost equally so.

By the year 1800 the steam-engine had not made such a transformation in industry as is often imagined, nor, on the other hand, was it so defective as to be relatively unimportant.[1] It was the new industries, cotton manufacture, engineering, and mining, and the new businesses that were setting up in the old industries, that first used the steam-engine, and all these new firms were free to select their own sites, and they fixed them to a very large extent on the coal-fields. This leads us to the second important fact in eighteenth-century history: the presence in England of large coal deposits and the development of their working by means of steam-power. This unlocking of the British coal seams changed Britain from "a small, poor, backward, and stagnant nation," into a great manufacturing state. The inter-dependence of the various movements of the mechanical revolution is very obvious.

The steam-engine provided power to drain the coal-mines, which supplied coal for the new methods of smelting iron; which, in turn, provided the additional supplies of metal for the construction of engines and machinery. By 1800, industry had reached its modern stage mechanically; there is

[1] Knowles. *Industrial and Commercial Revolutions.* p. 73.

no radical difference between the methods of 1800, and those of 1900. The old industries and methods were dying out and new ones were growing. The passing of the iron industries of Hampshire and the Weald, and the decay of the woollen industries of Norfolk and the West Country, are witnesses to it.

The Industrial Revolution, though impossible to separate from the mechanical changes involved in the introduction of the steam-engine, yet meant other and greater alterations in the structure of industry; these are social and economic changes in the position and relations of capital and labour. In mere volume, both capital and labour had increased tremendously during the century. The capital of the country had more than doubled itself since 1740, while the population had increased by nearly 50 per cent.

The increase in population had been made possible by the enclosure movement that added greatly to our production of food, and by the improvement in transport, resulting from the development of canals and the increase of turnpike roads, which enabled more produce to be brought to the market. The actual causes of the rapid increase in population are obscure and complicated, but are probably bound up with increased food supply, improved transport, and earlier marriages as a result of earlier wage-earning.

The increase in capital was due, in first place, to the presence of constructive ideas in the minds of the people living in England. Professor Marshall has stressed the great importance of the "idea,"

and the relative unimportance of the actual " things we possess," as a result of the idea.

Secondly, the century had seen the transformation of England from an agricultural state, adding to its capital chiefly by the produce of the land (especially wool), to an industrial state, developing capital from its coal and iron-fields. While, lastly, the improvement in the means of collecting and using capital, in the shape of banks and insurance companies, had greatly added to the facilities for increasing capital. Moreover, the increase in population and the new steam-power reacted on the increase of capital, the progress of the latter being impossible without the progress of, at least, one of the other two. The mechanical revolution was then accompanied by a rapid increase in both capital and labour (population), and deeply affected the relation of the two factors in production, and also their individual internal development.

As a result of the increase in population and the progress of the enclosure movement, large numbers of the labouring classes lost their stake in the land, and at one fell swoop were not only released from ties that held them in one place, but also lost the security, which a share in the common land had previously given them, against unemployment. They were forced into industry in large numbers; and they were unskilled. It was fortunate for this new large proletariat that industry was ready to receive them. The development of machine industry, especially in the textiles, had created a demand for large numbers of unskilled hands, who could

easily learn the simple duties attached to watching a machine. This meant that the class which lost by enclosure was forced to specialize in industry, just as the class that benefited by it had to specialize in agriculture.

The new working-class was composed largely of men who had no trade, and had no place in the traditional organization of industry. The demand for labour was for skilled and unskilled men during the last fifty years of the century. The industries, largely non-textile, which needed skilled labour, were gradually educating sufficient men for their purpose, and laying the foundations of the strong section of labour which made the unions of engineering and iron trades so important in the succeeding century. In the other trades, especially the textiles, it was generally true that the better the machine, the less intelligent the labour which was needed to look after it. The change which had come over industry was the origin of the unceasing complaint that workmen are less skilled, that has come down to us to-day. Previously, all artistic and technical skill had depended on the individual workman, and the skill of one generation might be lost in the next; but with the introduction of machinery and its gradual improvement, all advances became cumulative, the point attained by one generation, was the starting-point for the next. Machinery also meant an increase of speed; instead of every screw having to be made separately,[1] machines made them in hundreds; Adam Smith's pin factory

[1] Watt to Hornblower, January 20, 1777. Tangye MSS.

tells the story of this increase in the speed of production. Moreover, better roads and canals increased the rapidity of transport, then followed rapid growth of industry, quick returns to capital invested, and quick growth of the newly rich.

Moreover, both in textiles and non-textiles, division of labour and specialization was rapidly penetrating, and this development was immensely hastened by the invention of specialized machines. The state of the cotton mills, at the beginning of the nineteenth century, has been a reproach to the capitalist system ever since, and it has been blamed by humanitarian reformers and writers for the unspeakable conditions of the mills. However, it seems rather difficult to accuse the new capitalists of deliberately treating their employees as they are reputed to have done. There are some excuses to be made.

In the well-established trades, and those that continued their evolution normally with the assistance of steam-power, the paternal nature of the employers' duties was still realized. The separation of classes had become more and more complete as the amount of capital required to start in business increased. In 1750 there were few intermediaries between employer and employed, the capitalist still combined the functions of foreman, employer, and merchant.

The number of different processes carried on by one large employer, and the increase in the ground to be covered in supervision, made the introduction of wage-earning foremen and managers essential.

This movement developed outside the textiles, but owing to the rapid rise of even the smallest capitalist, soon became, of necessity, an integral part of the textile organization. This was, in a sense, an unsatisfactory development for the workman, for it meant that special qualities of intelligence or skill often only obtained a slightly superior post for their owner, who instead of rising to the class of master, merely exercised his skill for the large capitalist.

The separation of functions was still going on, the industrial capitalist was becoming merely an organizer, his function as foreman and manager had descended to wage-earners, and further economic classes had been evolved. This is the story of the end of the eighteenth century, and for the textiles it had disastrous results. The cotton mills contained collections of unskilled machine-tenders lacking any traditional organization, and having no relations with their employers save the weekly cash payment. The employers, in many cases, were illiterate, and careless of their responsibilities, but their carelessness was not wilful, they had never realized that they had any responsibilities, and it was natural that the only discipline to be imposed was imposed to further the immediate good of the trade.

The increased separation of employer and employed, closer book-keeping, the separation of classes, and the development of competitive economics, were inevitable causes of the misery of the next years. In the industries where the paternal character of the employer *gradually* evolved a decentralized

system of control over his works, no such bad effects are seen. But even in long-established manufactures, the new-comers were greedy of quick-returns, and the field of labour was treated as the earliest American settlers did the new lands they found ; they robbed the soil, got all they could out of it, and then moved on to virgin tracts. To the capitalists of the early nineteenth century, there seemed an unlimited supply of labour, and they did not notice the wastage.

The outlook of the century alters as it progresses through the Industrial Revolution. The economic, as opposed to all the other motives, takes the lead in moving men's actions. The development of free competition meant the development of disregard for motives of religion, patriotism, and sentiment. Logically such a result was to be expected, and so was unavoidable. Wars are delayed because nations have insured themselves.[1] Arms and goods are sold to opponents,[2] the enemies' ships are insured,[3]

[1] *Aris's Birmingham Gazette*, March 23, 1778. "Though a French War is now deemed by all parties inevitable, yet it is said that a Declaration of it will not take place on the part of Great Britain for a fortnight to come, as it has been represented to administration that the French have entered into policies in the City to the amount of near a Million which they will derive through their agents if we declare war before the first of April next."

[2] Puritan Birmingham sold arms to the Pretender in 1745 but had refused Prince Rupert a hundred years before. Boulton traded with France while we were at war.

[3] *Essay on the Science of Insurance whether it be nationally advantageous to insure the ships of our foreign enemies*, 1797, p. 7–61. During the French War British insurance was made for the French West India commerce, which, as a consequence, they did not trouble to convoy.

and the dictates of humanity are disregarded in relations with work-people.

The competitive spirit, while it made great improvements, also brought with it a dead weight of abuses. The self-interest it aroused begot and increased the quarrels of the various trades against protection. The quarrels between the producers and users of raw material, and between the consumers and producers of various commodities, with regard to duties and bounties, proved the impracticability of a protected system. Moreover, the economic survival of the strongest, that was becoming the usual story of industrial success, made men afraid. It was among the employers and capitalists that this fear first showed itself : it was a fear of natural causes and of other men ; they were not yet accustomed to the longer waits that were becoming necessary before complete returns came to reward the risker of capital. This fear was countered by insurance and combinations of employers for various purposes. Manufacturers tried to get control of the supply of raw material, while the producers of raw materials endeavoured to control the market for their produce. On both these points, the history of the Cornish copper mines and their struggle with those of Anglesea, and the subsequent efforts of Boulton in the matter of his contract for a copper coinage, are typical of a much more general movement. The organization of Chambers of Commerce is another effect of the same cause.

This development of competitive economics concentrated the attention of the country on money.

Money was wealth,[1] gain was everything, and industrial gain was the nearest and commonest way of becoming wealthy.

The development of large scale enterprise and big businesses needed the use of improved credit facilities, and innovations and developments were made gradually by optimistic and reliable business men in co-operation with liberal-minded bankers. The end of the eighteenth century had its period of speculation, but it differed from the madness from the South Sea Bubble, in that it was speculation in "industrials"; canals and public works were desirable stocks on 'change. Money, instead of being invested in commerce, was invested in manufacture, and the return seems to have been increasingly great.

Industrial investments soon became more important than commercial, and the banks spread into the provincial towns. There had been scarcely a bank outside London in 1750. In 1800 Manchester alone possessed some seven or eight.[2] The manufacturers no longer needed to go to Amsterdam for capital, as had been Boulton's fate in the earlier stages of the capitalization of the steam-engine firm. The bankers collected the money in London, and lent it out into the industries; their organization was more complex, and the services they rendered became more important, and if the realization of the power of the credit system was followed by its abuse, the abusers perished and bequeathed their experience to their successors.

[1] Arthur Young, *Political Arithmetic, passim.*

[2] L. Grindon, *Manchester Banks and Banking*, ch. i–v.

Both in banking and industry an advance in business organization took place, accuracy began to take the place of the old rough-and-ready methods. In fact, accuracy was the third important development of the century. Accurate machinery for industrial purposes was accompanied by a development of accurate machinery for office work. Book-keeping became a science, and Watt's copying machine supplied a pre-existing want.[1]

Side by side with this development of capitalist, industry, and organization, came an alteration in, or, at least, an extension of the classes who possessed capital. The erection of the national debt and the rapid increase in the number of joint-stock companies, accompanied by a growth in the total amount of capital, must have greatly extended the number of security holders, and after the half-dozen generations that had elapsed since the Bank of England had been established, many people in humble stations must have been owners of scrip. The system of investment was already well established, and was beginning to cut across the lines of separate development that were being followed by capital and labour. The ownership of capital was rapidly ceasing to mean direct control over industry. This was partly due to the length of time over which return to capital was spread. The earlier joint-stock companies had had as their objects a comparatively short commercial voyage,

[1] It is worth noting that only the improvement in and development of administration made possible the complicated social legislation of later centuries.

in which the capital and interest were soon repaid,[1] but the establishment of the national debt meant that many people invested money in war, and were well paid for so doing. During the eighteenth century the type of capital changed. From being commercial, a preponderating amount of it became industrial; and from being a floating circulating capital, the development of machinery, especially steam-power, caused it to become increasingly a fixed capital invested in certain definite things, from which it could rarely be released. This increase in the amount of fixed capital is one of the developments which was carried on by the advent of the steam-engine.[2] It became necessary that if a firm was to compete in the open market, it needed to use the power that its competitors used, and the first necessity for many industries became its power unit. Boulton told Boswell that he sold what all men desire—power. The increase in the amount of fixed capital made investments permanent, and the regularity of the income derived from them became important.

The great increase in vested interests following this development made Parliament the scene of many industrial quarrels; moreover, the permission of Parliament was necessary before many undertakings could be begun. Politics are becoming increasingly dependent upon economics, and the

[1] Scott, *op. cit.*, Vol. I, *passim.*

[2] It is important to observe that much of the new capital was found by the profits of the industry concerned, and that the sums originally invested were strikingly small compared with the developed capital.

influence of industrial capitalists is rapidly increasing in the House of Commons. In fact, the industrial element, represented by men like Whitbread and Peel, was an increasing factor in the lower House and even among the Peers, many of whom were interested in industry because they themselves possessed coal-mines or rights in them; instead of petitioning the House of Commons, as had been the method previously, industry began to influence—if not control—the representative assembly. That the direct representation of industry in the House remained small, at least up to 1860, is probably due to the increasing interest in trade of the land-owning party.[1]

Political economy, too, had become a subject of almost universal interest among the capitalist class; rarely have so many pamphlets on a subject been issued as those on questions of political economy, between 1770 and 1820. Amidst the welter of a chaos of economic misconceptions, men were gradually beginning to realize that the economic organization of a country was an organism, and that its development was, to a very large extent, beyond their control, due to the lack of certain knowledge of economic truths, a lack which persists to-day. A movement may be undesirable or even dangerous in the eyes of those whom it will affect, but unless they have sufficient know-

[1] In *Essays on Reform.* Cracroft, *Analysis of the House of Commons*, p. 164: "The mercantile manufacturing and shipping interest, including also owners of collieries, have . . . 122 members in the House. Half the peerage have mercantile and manufacturing interests" (p. 171).

ledge, any efforts at control or diversion may be nugatory.

The introduction of steam-power rapidly increased the speed of development of many movements that had already begun at the time of its invention. Accumulation of capital, extension of the proportion of fixed capital, the organization of industry on the coal fields, the development of a landless, wage-earning proletariat, were all hastened by steam-power, and if some of them had unhealthy infancies, perhaps the fact of their being born out of due season may be held to be, in some ways, the cause.

It is commonly held that the Industrial Revolution dealt a fatal blow to the lingering economic organization of mediaeval Britain, with its isolated districts, its dispersed manufactures, its lack of specialization, and its paternal regulation of trade and industry. It seems easier to say that England was already half-way out of its mediaeval restrictions, and that the mechanical revolution of the eighteenth century only hastened its emergence.

The inevitable character of many economic movements, however, does not answer other charges that have been levelled against those who took a leading share in the Commerce and Industry of the nineteenth century. " What commercialism has to answer is this : What have you done with the ideas of great men ? What have you accomplished with the weapons of science ? What have you to show in actual production in 1914 ; one hundred and forty-five years after James Watt took out his

steam-engine patents, and eighty-five years after Geo. Stephenson ran his ' Rocket ' in the Rainhill Competition ? "[1] and whether the world comes out of the inquiry with flying colours, or with shame and confusion, it seems impossible to blame the earliest pioneers in the field of modern industry for the tragedy and pain that follow in their track.

Utilitarianism was a practical philosophy in industry and business long before it was enunciated by Jeremy Bentham, and individuals, who were the authors of the Industrial Revolution, were seeking after their own happiness, and they did, in fact, in striving for this, confer great boons on their fellow-men. The failure of the State to recognize that utilitarianism alone was a hopeless philosophy for a nation, and the pre-occupation of the Government with foreign wars, allowed all the worst effects of the development of capital and capitalism to appear. Thus it was that philanthropic and honourable capitalists, like Wedgwood and Boulton, left to prosperity not only the improvements in production and the development of industry which had constituted their life's work, but also the burden of poverty, which rested heavily on the lower classes, and the doctrine of exploitation, which placed the lives of the poor in the hands of their economic over-lords.

In the year 1800 the steam-engine is on the verge of penetrating every department of industry, all the elements of progress are working, and the seeds of social unrest are as yet quietly underground ;

[1] Chiozza Money, *The Future of Work*, p. 22.

the capitalist class already exists, and the machinery of industrial credit is working more smoothly as precedents accumulate and industry and banking unite ever more closely in the development of national resources.

In conclusion, it is worthy of notice that the innovations, introduced by a few energetic and capable men, fallen in fruitful soil, have done more to revolutionize the world than all the ideas of liberty, fraternity, and equality. Boulton has defeated Rousseau, the workmen of Soho and Etruria have a greater influence than the Paris mob, and the banking transactions of Lowe, Vere, & Williams assume a greater significance than the debates of the States General.

APPENDIX

As there were many inquiries for engines that never resulted in an order or the erection of an engine, it is worth recording a list of the early inquiries received by Boulton & Watt, to show what sort of industrial enterprises felt the need of steam-power, even though from lack of capital or some other reason no engine was at the time erected.

Date of Inquiry.	Name of Inquirer.	Purpose of Engine.	Place of Erection.	Kind of Engine.
Oct. 18, 1775	John Collet ..	Polishing mill	London ..	Rotary
„ 22, 1775	John Bligh ..	Water-works..	Chelsea ..	Reciprocating
	— Winchester	Mine	Bakewell ..	„
	B. Wilbie ..	Distillery ..	Stratford-le-Bow	„
Dec. 14, 1775	J. Scott ..	Colliery ..	Shrewsbury ..	„
Feb. 16, 1776	S. Garbett ..	Iron-works and colliery ..	Carron ..	„
July 3, 1776	J. Cross & Co.	Distillery ..	Bristol ..	„
„ 26, 1776	Chas. Cash ..	Private water Supply ..	.. .. ..	„
„ 30, 1776	T. Williams ..	.. .. ..	Haverfordwest	„
Aug. 30, 1776	Sir A. Hope, Bt.	.. .. ..	Newton, near Edinburgh	
Oct. 28, 1776	C. Howard, Engineer ..	Iron-works ..	Hawarden, Flint	„
„ 28, 1776	Stewart ..	Private water supply ..	.. .. ..	„
„ 28, 1776	S. Wyatt ..	Private water supply ..	.. .. ..	„
Nov. 2, 1776	Shadwell Waterworks ..	.. .. ..	Shadwell ..	„
„ 2, 1776	West Ham Water-works	.. .. ..	West Ham ..	„
„ 8, 1776	Engine to be erected free	Mine (Tin or Copper)	Cornwall ..	Reciprocating
„ 8, 1776	L. Langdale ..	Raising water	Holborn ..	„
„ 8, 1776	Proctor & Beilby	Mill	Sheffield ..	Rotary
„ 10, 1776	F. L. Kaller ..	Mine	Landshut, Silesia ..	Reciprocating
„ 12, 1776	Henshall ..	Colliery ..	Lawton, Cheshire ..	„
„ 12, 1776	Matthews ..	Mine	Broseley, Salop	„
„ 26, 1776	Beech	Colliery ..	.. .. ..	„

Date of Inquiry.	Name of Inquirer.	Purpose of Engine.	Place of Erection.	Kind of Engine.
Feb. 16, 1777	Salmon ..	Brine Works..	Hassall, Cheshire ..	Reciprocating
[1] „ 22, 1777	Chapman ..	Colliery ..	Newcastle-on-Tyne ..	„
—	Colville ..	„ ..	Torryburn ..	„
Feb. 27, 1777	[?]	„ ..	Coseley ..	„
March 1, 1777	Wilson.. ..	Copper mine..	Chacewater, Cornwall ..	„
„ 6, 1777	Bockett & Janson	.. .. ..	Southwark ..	„
April 2, 1777	Gambrell ..	Carpenter's shop	Richmond, Surrey	Rotary
„ 8, 1777	T. Wrothall ..	.. .. ..	Woodhouse, nr. Sheffield ..	„
„ 8, 1777	T. Warden ..	.. .. ..	Macclesfield ..	„
„ 24, 1777	G. Meason ..	Colliery ..	Edinburgh ..	Reciprocating
July 17, 1777	Richmond ..	Water-works..	Richmond ..	„
Aug. 13, 1777	Ph. Clowes ..	Silk mill ..	Chesterfield ..	Rotary
„ 18, 1777	Burgess ..	Water-works..	Borough water-works ..	Reciprocating
Nov. 30, 1777	Arkwright ..	Feed water wheel	Cromford ..	„
Dec. 31, 1777	Reynolds ..	Iron works ..	Ketley ..	„
[2] April 16, 1778	M. Wright ..	.. .. ..	Hull	„

[1] At this date five engines were working. *Vide supra*, p. 154.

[2] Smeaton received the contract for erecting this engine, but having seen the Boulton & Watt engine at the Birmingham Navigation, surrendered the Hull engine contract to Boulton & Watt.

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